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OF

HARVARD COLLEGE.

EDWARD C. PICKERING, DIRECTOR.

CIRCULARS

101 TO 150

CAMBRIDGE, MASS.

Published by the Observatory

1909.

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HARVARD COLLEGE OBSERVATORY.

CIRCULAR 101.

POSITIONS OF OCLLO (475) DURING 1904.

- IN Circular 63, a new asteroid was announced which, from its great southern declination, — 62° , appeared to be of unusual interest. An orbit was computed, based upon a series of photographs extending from August 5 to November 13, 1901, and this showed that the eccentricity was greater than that of any other asteroid hitherto discovered. In this respect, therefore, it forms a connecting link between the asteroids and periodic comets. Photographs were taken by Professor Wolf of Heidelberg on January 18, and February 17, 1903, and an object measured which was supposed to be Ocllo (Astron. Nach. 161, 291). As this object proves not to be Ocllo, an ephemeris for 1905 was computed under the direction of Professor Krentz (Astron. Nach. 167, 349) and Mr. R. H. Frost, in charge of the Arequipa Station of the Harvard Observatory, was requested to photograph the region with the Bruce Telescope. There might be danger that this interesting object would be lost, but fortunately two photographs were taken at Arequipa in 1904, and Ocllo marked upon one of them. Measures of Ocllo on both of these plates have been made by Mrs. Fleming and the results are given in Table I. On each date, Ocllo leaves a trail, and the positions of the two ends of these trails are given in the table.

TABLE I.

OBSERVED POSITIONS.

Date.	G. M. T.		R. A. 1855.			Dec. 1855.	
1904.	<i>h.</i>	<i>m.</i>	<i>h.</i>	<i>m.</i>	<i>s.</i>	$^{\circ}$	$'$
April 4	13	24	11	51	37.2	+17	56.4
" "	14	54	11	51	35.9	+17	56.7
April 7	13	20	11	49	36.9	+18	4.8
" "	14	20	11	49	35.2	+18	5.0



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The asteroid was compared on each plate with nine adjacent Durchmusterung stars. The average deviation of the results derived from the individual stars was about $\pm 0^s.8$ in right ascension, and $\pm 0'.3$ in declination. A large part of these deviations was due to errors in the Durchmusterung positions. On April 7 a star of about the fifteenth magnitude, R.A. = $11^h 49^m 34^s.5$, Dec. = $+18^\circ 5'.1$ (1855), was so nearly in line with the trail of the asteroid that at about $14^h 44^m$, G.M.T., the asteroid was about one second north of the star. It will be noticed from the Berlin Jahrbuch for 1906, page 443, that the computed position of Oello precedes the observed position by about five minutes of time, and is north of it more than two degrees. The daily motion, however, is nearly the same, and there was no other known asteroid in this part of the sky.

EDWARD C. PICKERING.

JUNE 27, 1905.

HARVARD COLLEGE OBSERVATORY.

CIRCULAR 102.

POSITIONS OF PHOEBE IN MAY, 1905.

A LETTER recently received from Mr. R. H. Frost states that he has photographed Phoebe on four nights, with the 24-inch Bruce Telescope. The name of the plate, the date, the Greenwich Mean Time of the middle of the exposure, and the exposure in minutes are given in the first four columns of Table I. The observed distance of Phoebe from the centre of Saturn, and the observed difference of declination are given in the fifth and sixth columns. The corresponding position angle is given in the seventh column. A comparison was next made with the ephemeris computed by Dr. Ross, and given in Harvard Annals, 53, 141. The differences found by subtracting the computed from the observed distances and position angles are given in the eighth and ninth columns.

TABLE I.
POSITIONS OF PHOEBE.

Plate.	Date.	G. M. T.		Exp.	Dist.	Diff.	P. A.	Dist.	P. A.
	1905.	<i>h.</i>	<i>m.</i>	<i>m.</i>	<i>'</i>	<i>'</i>	<i>°</i>	<i>'</i>	<i>°</i>
A 7300	May 9	21	3	112	10.6	+ 5.8	56.8	- 0.4	+ 2.2
A 7303	" 10	20	40	120	11.0	+ 6.4	54.4	- 0.3	- 0.5
A 7307	" 12	20	49	120	11.6	+ 6.3	57.1	- 0.3	+ 1.4
A 7308	" 13	20	48	145	12.0	+ 6.6	56.6	- 0.3	+ 0.6

It will be seen from this table that on the mean date, May 11, the computed distances should be diminished by 0'.3, and the position angles increased by 0°.9. The average deviations of the observed values, on different nights, are less than a tenth of a minute in distance and a degree in position angle. So far as known, these are the only observations of Phoebe that have been obtained since last autumn.

EDWARD C. PICKERING.

JULY 1, 1905.

HARVARD COLLEGE OBSERVATORY.

CIRCULAR 103.

POSITIONS OF OCLLO (475) DURING 1905.

A LETTER recently received from Mr. R. H. Frost at Arequipa gives the following account of recent observations of Oello (475):—

“Since receiving the ephemeris of Oello we have used most of the dark nights for the search for this object, and at last think we have found Oello in the following positions:—

Plate A 7335,	June 6.7142,	G. M. T.,	Exposure 90 ^m ,	R.A. 15 ^h 43 ^m 24 ^s ,	Dec. -39° 29'.1,	(1875).
“ A 7337,	“ 7.6146,	“	“ 90 ^m ,	“ 15 ^h 42 ^m 01 ^s ,	“ -39° 32'.3,	“
“ A 7342,	“ 9.7088,	“	“ 90 ^m ,	“ 15 ^h 38 ^m 46 ^s ,	“ -39° 40'.6,	“

The above measurements and computations were made by Mr. Manson. Oello, therefore, seems to be about four degrees from its computed position. We should have found the asteroid somewhat sooner, but the use of the ‘Planet Apparatus’ cuts down the field to such an extent that it requires four times the number of plates to cover the regular field. We had laid out a scheme of nine plates about the ephemeris position as a centre, and the asteroid was found on the eighth plate taken in the series. We shall try to get two more plates on this object, as soon as the Moon allows, and then two more just before the Moon interferes again, continuing this plan as long as the region may be conveniently reached.”

The observations contained in Circulars 63, 101, and 103, should serve to determine the elements of the orbit of Oello with accuracy, and render the loss of this asteroid, at any future time, improbable.

EDWARD C. PICKERING.

JULY 15, 1905.

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COMPARISON STARS.

Desig.	DM.	R. A. 1855.	Dec. 1855.	DM.	Ptg.	Desig.	DM.	R. A. 1855.	Dec. 1855.	DM.	Ptg.
		<i>h.</i> <i>m.</i> <i>s.</i>	<i>°</i> <i>'</i>					<i>h.</i> <i>m.</i> <i>s.</i>	<i>°</i> <i>'</i>		
Var.	+27° 623	3 54 59.8	+27 43.3	8.2	7.14	l	.. ...	3 53 54.8	+27 38.2	..	9.98
a	+28° 609	3 52 31.1	+28 5.3	6.7	6.57	m	+27° 619	3 53 54.6	+27 47.5	9.5	10.08
b	+27° 628	3 56 19.1	+27 12.2	7.8	7.32	n	.. ...	3 54 36.7	+27 42.7	..	10.43
c	+27° 618	3 53 21.6	+27 43.8	7.5	7.70	o	.. ...	3 54 13.2	+27 33.4	..	10.58
d	+27° 629	3 56 34.7	+27 29.7	7.8	8.05	p	.. ...	3 54 34.6	+27 43.8	..	10.98
e	+28° 610	3 54 3.5	+28 3.0	8.3	8.27	q	.. ...	3 54 59.2	+27 44.0	..	11.26
f	+27° 630	3 56 43.8	+27 59.6	8.8	8.52	r	.. ...	3 54 58.6	+27 41.9	..	11.58
g	+27° 621	3 54 7.0	+27 16.3	9.1	8.74	s	.. ...	3 55 17.6	+27 42.7	..	11.78
h	.. ...	3 54 2.7	+27 52.2	..	9.46	t	.. ...	3 55 2.0	+27 38.3	..	12.15
k	+27° 622	3 54 54.8	+27 59.9	9.3	9.58						

2.76886 E, are given in the sixth and seventh columns. Two corrections must be applied to these phases, the first for the velocity of light, the second for the light curve. The first of these is small, never exceeding $0^d.006$, and may be applied directly from Table III, the second is as yet insufficiently determined. It seems better therefore to leave the results uncorrected until the form of the light curve can be determined by a continuous series of photographs taken near the time of minimum.

Table III gives the correction for the light equation, or the amount to be added to the observed time to give the heliocentric time of observation.

TABLE III.
LIGHT EQUATION.

Dates.		Corr.	Dates.		Corr.	Dates.		Corr.
Jan. 1 — Jan. 14		+ .004	April 1 — April 15		— .004	Aug. 24 — Sept. 1		.000
Jan. 15 — Jan. 25		+ .003	April 16 — May 6		— .005	Sept. 2 — Sept. 11		+ .001
Jan. 26 — Feb. 6		+ .002	May 7 — June 13		— .006	Sept. 12 — Sept. 22		+ .002
Feb. 7 — Feb. 17		+ .001	June 14 — July 4		— .005	Sept. 23 — Oct. 4		+ .003
Feb. 17 — Feb. 27		.000	July 5 — July 23		— .004	Oct. 5 — Oct. 19		+ .004
Feb. 28 — Mar. 9		— .001	July 24 — July 31		— .003	Oct. 20 — Nov. 12		+ .005
Mar. 10 — Mar. 20		— .002	Aug. 1 — Aug. 11		— .002	Nov. 13 — Dec. 8		+ .006
Mar. 21 — Mar. 31		— .003	Aug. 12 — Aug. 23		— .001	Dec. 9 — Dec. 31		+ .005

An ephemeris giving the Greenwich Mean Time of the minima occurring during the next three months is given in Table IV.

TABLE IV.
EPHEMERIS.

E.	J. D.	G. M. T.	E.	J. D.	G. M. T.	E.	J. D.	G. M. T.
		<i>h. m.</i>			<i>h. m.</i>			<i>h. m.</i>
2545	7048.858	July 21 20 36	2555	7076.546	Aug. 18 13 6	2565	7104.235	Sept. 15 5 38
2546	7051.627	" 24 15 3	2556	7079.315	" 21 7 34	2566	7107.003	" 18 0 4
2547	7054.395	" 27 9 29	2557	7082.084	" 24 2 1	2567	7109.772	" 20 18 32
2548	7057.164	" 30 3 56	2558	7084.853	" 26 20 28	2568	7112.541	" 23 12 59
2549	7059.933	Aug. 1 22 24	2559	7087.622	" 29 14 56	2569	7115.310	" 26 7 26
2550	7062.702	" 4 16 51	2560	7090.390	Sept. 1 9 22	2570	7118.079	" 29 1 54
2551	7065.471	" 7 11 18	2561	7093.159	" 4 3 49	2571	7120.848	Oct. 1 20 21
2552	7068.240	" 10 5 46	2562	7095.928	" 6 22 16	2572	7123.616	" 4 14 47
2553	7071.009	" 13 0 13	2563	7098.697	" 9 16 44	2573	7126.385	" 7 9 14
2554	7073.777	" 15 18 39	2564	7101.466	" 12 11 11	2574	7129.154	" 10 3 42

The position of this variable for 1900 is R.A. = $3^h 57^m 45^s.27$, Dec. = $+27^\circ 50' 59''.7$. Its designation is, therefore, 035727. It is in the constellation Taurus, and of the variables discovered here, it is II 1174. Its spectrum, like that of other Algol variables, is of the first type. On the map of the sky, Plate 12, its light is normal, and its position is [95, 90].

EDWARD C. PICKERING.

JULY 28, 1905.

HARVARD COLLEGE OBSERVATORY.

CIRCULAR 105.

A. G. C. 6886. STAR HAVING A LARGE PROPER MOTION.

THE method of superposing photographic plates, taken on different dates, upon a glass positive covering the same region, used for the discovery of variable stars as mentioned in Circular 79, is valuable as a means of detecting any other obvious changes in the region. In Circular 96, announcement was made of a star in the Small Magellanic Cloud which was found in this way to have a large proper motion. During a recent examination of the Large Magellanic Cloud, the star A. G. C. 6886, magn. 8.5, was found by Miss H. S. Leavitt to have moved noticeably, between April 11, 1898, and December 5, 1904. An examination of the different catalogues containing this star, confirms its rapid motion. Measures of its position have been made on Plate B 5720, October 12, 1890, exposure 57^m, and on Plate B 34996, October 21, 1904, exposure 10^m, both taken with the 8-inch Bache Telescope. The positions derived from these measures, and those in the different catalogues, reduced to the epoch 1875.0, are given in Table I. The name of the catalogue or photographic plate and the number of the star are given in the first column, and the date of observation, expressed in years and hundredths, in the second. As no dates are assigned for the observations in Brisbane's Catalogue, beyond the statement that they were made principally in the years 1822, 1823, 1824, 1825, and 1826, the epoch of the catalogue, 1825.0, has been assumed as the time of observation. The observed right ascension and declination are given in the third and fourth columns. The declination as given in Brisbane's Catalogue is 5' too far north, and a correction of this amount has been applied. Brisbane 1065 has the correct declination but

TABLE I.

Designation.	Date of Obs.	R. A. 1875.			Dec. 1875.			Corr. R. A.	Corr. Dec.	Res. R. A.	Res. Dec.
		<i>h.</i>	<i>m.</i>	<i>s.</i>	<i>°</i>	<i>'</i>	<i>''</i>				
Brisbane, 1070	1825.	5	46	1.79	-70	14	55.1	58.5	58.	-0.4	-6.
Gillis, 3460	1851.53	46	0.48			14	18.9	58.93	52.1	0.00	-0.4
Z. C. 5 ^b 1750	1874.09	45	59.13			13	52.4	59.07	51.4	+0.14	+0.3
A. G. C. 6886	1878.07	45	58.60			13	48.1	58.80	51.6	-0.13	+0.1
C. P. D. -70° 447	1886.09	45	57.0			13	42.	57.7	55.	-1.	-3.
B 5720	1890.78	45	57.87			13	33.8	58.91	51.8	-0.02	-0.1
B 34996	1904.81	45	56.97			13	17.6	58.94	51.6	+0.01	+0.1

the wrong right ascension. In discussing these positions, for the purpose of determining the amount of the star's proper motion, the catalogue of Brisbane was omitted on account of these uncertainties as to time and position. The Cape Photographic Durchmusterung was also omitted, because the positions were not sufficiently precise for comparison with other catalogues. Assigning equal weights to the remaining five positions, it has been found that the motion in right ascension may be closely represented by the formula $\Delta \alpha = -0^s.066 t$. The fifth column gives the right ascension, corrected by this formula, in seconds of time following $5^h 45^m$. The motion in declination may be represented by the formula $\Delta \delta = +1''.14 t$, and the corrected declination is given in the sixth column in seconds of arc south of $-70^\circ 13'$. The residuals from the means of the corrected right ascensions and declinations are given in the seventh and eighth columns. The average values of these residuals, omitting Brisbane's Catalogue and the Cape Photographic Durchmusterung, are $\pm 0^s.06$ and $\pm 0''.2$. The annual proper motion, as given above, is in right ascension, $-0^s.066$, in declination, $+1''.14$, in a great circle, $1''.28$.

For the purpose of showing this motion, Plates B 5710 and B 34996, mentioned above, were superposed, the star images not quite coinciding. The two plates were then enlarged to a scale of $40'' = 0.1 \text{ cm.}$, as shown in the



accompanying figure. Two images of each star are seen, the brighter of each pair belonging to the earlier of the two plates. The position angles of these two images are sensibly the same for all stars except A.G.C. 6886, seen in the centre of the figure.

The total number of stars clearly shown on the original negatives is about three hundred thousand. It is probable that none of these, except A.G.C. 6886, have an annual proper motion exceeding three quarters of a second.

EDWARD C. PICKERING.

HARVARD COLLEGE OBSERVATORY.

CIRCULAR 106.

H 1175. NOVA AQUILAE. No. 2. 18560.4.

A SECOND new star in the constellation Aquila has been found by Mrs. Fleming from an examination of the photographs of the Henry Draper Memorial. No trace of this star has been found on any photograph taken before August 18, 1905. It is important that this star should always be designated as No. 2 to distinguish it from Nova Aquilae No. 1, which was first photographed on April 21, 1899, was discovered in the same way, and was described in the Harvard Bulletin of July 11, 1900, and in Circular 56.

The principal facts concerning a number of photographs of the region containing Nova Aquilae, No. 2, are given in Table I. The first column gives the letters designating the series followed by the number, in that series, of each photograph. The letter A denotes that the photograph was taken with the 24-inch Bruce Telescope, B with the 8-inch Bache Telescope, C with the 11-inch Draper Telescope, I with the 8-inch Draper Telescope, and AC with the Cooke Anastigmat. The year, month, and day are given in the second column, the Julian Day and decimal in the third column, and the duration of the exposure in the fourth column. The photographic magnitude of the Nova is given in the fifth column for the later plates, and for the earlier plates the magnitude is that of the faintest star shown, preceded by the sign <, which denotes that the Nova was not seen and must have

TABLE I.
DESCRIPTION OF PHOTOGRAPHS.

Plate.	Date.			Julian Day.	Ex.	Magn.	Plate.	Date.			Julian Day.	Ex.	Magn.
	y.	m.	d.		m.			y.	m.	d.		m.	
B 2655	1888	5	22	0780.788	22	<12.1	AC 6590	1905	8	10	7068.678	85	< 9.7
B 2656	"	"	"	" .806	16	<12.3	C 15907	"	"	18	7076.635	75	9.07
B 3013	"	10	18	0929.487	16	<12.3	AC 6614	"	"	21	7079.602	63	9.27
I 1494	1890	7	20	1569.753	11	<12.0	AC 6632	"	"	26	7084.549	67	10.04
I 11185	1894	6	13	2993.726	19	<12.6	AC 6643	"	"	31	7089.547	60	10.28
A 1851	1896	6	17	3728.689	60	<13.6	I 33294	"	"	"	" .559	60	10.48
I 17844	1897	4	12	4027.857	10	<13.2	I 33295	"	"	"	" .608	60	10.43
A 6506	1903	8	15	6342.607	240	<15.7	C 15930	"	"	"	" .574	10	10.38
AC 6565	1905	8	2	7060.637	60	<11.5	C 15931	"	"	"	" .609	20	10.38
AC 6576	"	"	4	7062.572	58	<10.8	C 15933	"	"	"	" .663	30	10.38

REMARKS.

B 2655. The earliest plate available for this examination. It extends the work over seventeen years.

A 6506. This plate shows stars much fainter than any other photograph of the region. The region of the Nova is near the edge of the plate, otherwise, still fainter stars would probably have been shown.

AC 6590. The last photograph before the appearance of the Nova. The region is on the edge of the plate, which, in the centre, shows stars nearly as faint as AC 6565.

C 15907. A spectrum plate of α^2 4460, taken with one prism. The spectra of the stars α^1 1663, α^4 4669, α^5 4876, α^4 4684, and of the Nova are also shown. The Nova was discovered from this plate. Its spec-

trum, although faint, shows the lines H δ , H γ , 4272, 4646, and H β , very broad and bright. The lines H γ and H β have accompanying dark lines on the edge of shorter wavelength. These dark lines are still better shown in a contact print from the original negative. The helium line 4646 is slightly stronger than 4272. The entire spectrum therefore closely resembles that of Nova Persei, No. 2, on March 30, 1901. See *Annals* 56, No. 3, Plate I.

AC 6614. Images near edge of plate, and much enlarged.

AC 6632. This and the two preceding plates were taken after the Nova appeared, and before it was discovered.

133294. A spectrum plate. The spectrum of the Nova is substantially the same as that shown on C 15907.

been fainter than the magnitude given. The scale is that defined by the photographic magnitudes of the comparison stars, given in the last column of Table III. There are probably two or three hundred early photographs of the region, but only twenty-nine of them have been examined, as on none of them does the Nova appear. Only eleven of these plates have been included in Table I.

TABLE II.
MEASURES OF LIGHT.

Date.		Photometric.	Photographic.
August 31		10.32	10.41
September 1		10.41	10.42
"	5	10.60	10.58
"	6	10.57	10.63
"	8	10.65	10.86
"	9	10.76	10.86
"	13	10.65	...
"	14	10.91	10.77
"	21	11.14	11.16
"	22	11.55	11.23

Since the discovery of the Nova on August 31, photographs of it and visual measurements of its brightness have been made on every clear night. The dates, photometric magnitudes and photographic magnitudes, are given in Table II.

A list of the comparison stars is contained in Table III. In the first portion of the table which relates to the brighter stars, the first five columns give the designation, and the number, right ascension, declination, and magnitude according to the Durchmusterung, for the stars contained in that work. In the second part of the table, which contains the fainter stars, the second and fifth of these columns are omitted. The last two columns of the table give the photometric and photographic

magnitudes. The photometric magnitudes depend on measures made with the 12-inch meridian photometer for the stars a to o, and star r. Estimates were made, by Argelander's method, of the intervals between the stars and the magnitudes deduced as described in Volume 37. The magnitudes of stars fainter than r were obtained by extrapolation and are somewhat uncertain. The stars a and l, are much brighter visually than photographically. They have spectra of the second type. The other brighter comparison stars have spectra of the first type. The

star p is fainter visually, but brighter photographically, than q or r. The positions of the stars not contained in the Durchmusterung were found by laying a plate, ruled in squares a millimetre on a side, on A 6506 and estimating the coördinates in twentieths of a millimetre.

TABLE III.
COMPARISON STARS.

Des.	DM.	R. A. 1855.			Dec. 1855.		DM.	Pltm.	Pltgr.	Des.	R. A. 1855.			Dec. 1855.		Pltm.	Pltgr.
		<i>h.</i>	<i>m.</i>	<i>s.</i>	<i>°</i>	<i>'</i>					<i>h.</i>	<i>m.</i>	<i>s.</i>	<i>°</i>	<i>'</i>		
N	. . .	18	54	25.1	-4	38.6	. .	. .	. .	o	18	54	10.4	-4	38.0	12.10	11.90
a	-4° 4663		53	28.8	-4	38.4	6.8	6.98	8.67	p		54	41.0	-4	42.2	12.95	12.38
b	-4° 4668		54	11.9	-4	32.1	8.5	9.36	9.17	q		54	43.5	-4	42.6	12.38	12.69
c	-4° 4665		53	42.4	-4	52.5	8.8	9.42	9.57	r		54	34.3	-4	32.9	12.77	12.97
d	-5° 4844		54	57.2	-5	0.0	9.0	9.58	9.79	s		54	53.5	-4	40.3	13.53	13.27
e	-5° 4839		53	46.8	-5	10.0	9.1	9.96	9.89	t		54	33.5	-4	39.0	11.17	13.72
f	-4° 4675		55	21.2	-4	35.5	9.1	9.90	10.09	u		54	37.3	-4	40.5	13.98	13.97
g	-4° 4687		57	39.0	-4	41.7	9.2	10.02	10.17	w		54	30.3	-4	41.7	11.55	14.27
h	-4° 4656		52	5.1	-4	53.3	9.5	10.81	10.59	x		54	25.5	-4	39.8	14.98	14.62
k	. . .		54	18.3	-4	48.1	. .	10.68	10.67	y		54	25.1	-4	38.3	. .	14.82
l	-4° 4677		55	59.6	-4	43.8	9.2	10.26	10.95	z		54	29.0	-4	38.0	15.16	14.97
m	. . .		54	14.2	-4	37.7	. .	11.28	11.30	a		54	24.8	-4	39.0	. .	15.27
n	. . .		54	21.5	-4	32.5	. .	11.54	11.45								

It was at first thought that the Nova might be identical with star *a*. As the plates available for comparison were on different scales, it was difficult to determine by inspection whether this was the case. Plates A 6506 and C 15938 were accord-

TABLE IV.
ADJACENT STARS.

<i>x</i>	<i>y</i>	Magn.	<i>x</i>	<i>y</i>	Magn.	<i>x</i>	<i>y</i>	Magn.	<i>x</i>	<i>y</i>	Magn.	<i>x</i>	<i>y</i>	Magn.
"	"		"	"		"	"		"	"		"	"	
-111	+ 15	13.5	- 75	+ 39	15.0	- 15	+ 57	14.9	+ 47	-113	14.8	+107	+ 71	15.1
-107	- 25	15.2	- 66	- 17	15.2	- 6	+135	14.8	+ 48	+105	14.9	+111	- 96	15.0
-105	+ 54	12.0	- 66	- 30	15.2	- 5	- 18	15.3	+ 54	+ 96	15.0	+115	-102	15.2
-105	+ 43	14.2	- 65	- 78	15.4	- 1	+ 18	14.9	+ 63	+ 36	15.0	+120	-107	14.9
-102	+ 45	14.3	- 54	+ 84	15.0	0	0	Nova	+ 75	+ 67	15.0	+126	+ 93	14.4
- 99	+ 30	15.2	- 45	+123	15.4	0	+147	15.4	+ 79	+ 77	15.0	+126	+ 67	15.4
- 95	+126	15.0	- 41	+111	15.0	+ 6	- 72	14.6	+ 87	- 93	15.4	+126	-111	14.9
- 90	+ 12	14.8	- 36	- 71	15.2	+ 13	+126	14.8	+ 95	+109	15.2	+127	- 33	13.7
- 84	+ 96	15.2	- 30	+ 15	15.2	+ 18	+144	15.4	+ 96	+ 87	15.3	+132	+ 99	14.4
- 77	+ 75	14.9	- 15	+ 78	14.8	+ 29	+ 18	15.2	+ 96	+ 57	15.5			

ingly enlarged to the same scale, $10'' = 0.1$ cm. Superposing them, it was obvious that no star appeared on the first plate in the position of the Nova.

The positions and estimated photographic magnitudes of all the stars shown on A 6506, and not more than $2'$ distant from the Nova in right ascension or declination, are given in Table IV. The stars for which the values of x are $-5''$, $-1''$, $0''$, $+6''$, $+63''$, and $+127''$ are α , γ , Nova, ϵ , z , and t , respectively.

On the photographs taken on August 18 and 21, the Nova was nearly equal in brightness to the star α , $-4^{\circ}4663$, magn. 6.8. It was therefore at first supposed that the Nova was at least as bright as the seventh magnitude.

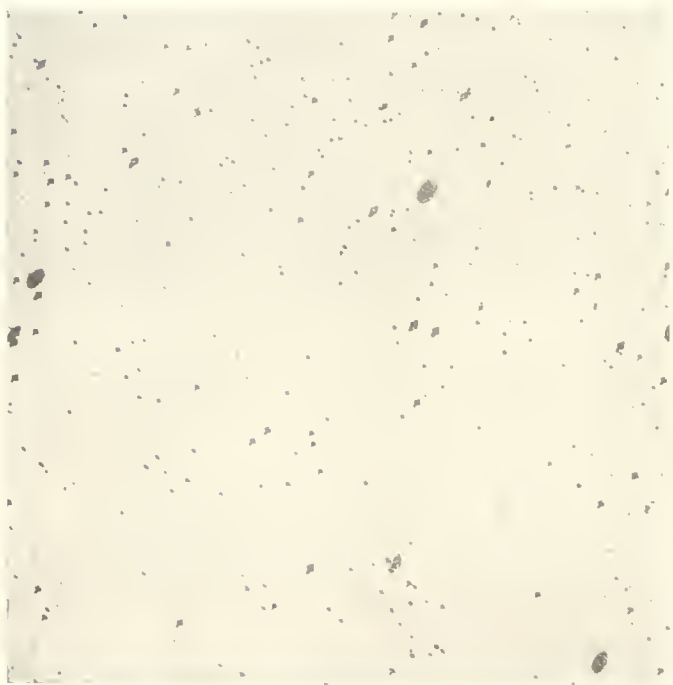


FIGURE 1.



FIGURE 2.

A region half a degree square, with the Nova as the centre, is shown in Figure 1, on a scale of $20'' = 0.1$ cm. It was obtained by enlarging A 6506 three times. The star z is faintly shown, but no object in the place of the Nova. A similar enlargement of I 33295 is shown in Figure 2. The Nova is the bright star in the centre.

It will be seen that the time during which the Nova made its appearance was between August 10, and August 18. This interval may be greatly reduced when the plates taken in Arequipa are received. As, however, the Moon was full on August 14, the number of plates taken at that time would be small.

EDWARD C. PICKERING.

SEPTEMBER 23, 1905.

HARVARD COLLEGE OBSERVATORY.

CIRCULAR 107.

TWENTY-FIVE NEW VARIABLE STARS.

A RECENT examination, by Miss Henrietta S. Leavitt, of plates taken with the 24-inch Bruce Telescope, has led to the discovery of a number of new variable stars, which are given in Table I. The six variables in Orion were discovered during the selection of comparison stars for the pair of interesting variables, H 797 and H 798, near σ Orionis. The discovery of the three variables in Virgo was made by superposing plates in the manner described in Circular 79. Six excellent plates, having exposures of about two hours, were used. The approximate centres of these plates are R. A. = $13^h 54^m$, Dec. = $-10^\circ.4$ (1900). The known variable, RR Virginis, was re-discovered at the same time. The sixteen variables in Cygnus are in the region of the great spiral nebula, whose most conspicuous portions are catalogued as N. G. C. 6960 and N. G. C. 6992. Together with the known variable UX Cygni, they were found by superposing five plates having exposures of from two to four hours. Of these, three have centres near R. A. = $20^h 45^m$, Dec. = $+30^\circ.5$, while those of the other two are near R. A. = $20^h 50^m$, Dec. = $+32^\circ.5$. All the plates are of extremely fine quality, and probably the images of at least 200,000 stars were clearly seen and compared. The successive columns of the Table give the Harvard number, the constellation, the right ascension, and the declination for 1900, the brightest and faintest magnitude so far observed, and the range.

The positions of the new variables in the Small Magellanic Cloud, as announced in Circular 96, have been measured, and observations of their brightness are in progress, with a view to determining their light curves. New variables are occasionally found in the course of this study, the number discovered in this region up to the present time being 970. A series of excellent plates covering the Large Magellanic Cloud has been received, and a preliminary examination indicates that it also contains variable stars in very great numbers. The study of this region is being carried on simultaneously with that of the Small Magellanic Cloud.

TABLE I.
NEW VARIABLE STARS.

Harvard No.	Constellation.	R. A. 1900.			Dec. 1900.		Br.	Et.	R.
		<i>h.</i>	<i>m.</i>	<i>s.</i>	<i>°</i>	<i>'</i>			
1176	Orion	5	33	26	—	2 49.5	15.6	< 16.4	0.8
1177	Orion	5	33	58	—	2 51.2	14.1	< 16.4	2.3
1178	Orion	5	34	25	—	2 43.6	15.0	16.3	1.3
1179	Orion	5	34	38	—	2 24.1	14.5	16.0	1.5
1180	Orion	5	34	38	—	2 34.6	15.0	15.5	0.5
1181	Orion	5	34	40	—	2 46.2	14.4	16.0	1.6
1182	Virgo	13	50	20	—	10 43.8	14.0	15.0	1.0
1183	Virgo	13	51	32	—	12 4.3	13.0	14.0	1.0
1184	Virgo	13	58	49	—	9 31.2	13.0	14.0	1.0
1185	Cygnus	20	40	29	+31	58.0	14.1	14.7	0.6
1186	Cygnus	20	42	27	+30	36.2	14.2	15.0	0.8
1187	Cygnus	20	42	42	+31	23.9	13.6	14.3	0.7
1188	Cygnus	20	43	8	+30	50.4	12.6	14.1	1.5
1189	Cygnus	20	43	30	+31	21.8	13.8	14.9	1.1
1190	Cygnus	20	44	0	+32	42.5	14.0	14.9	0.9
1191	Cygnus	20	44	56	+31	28.8	10.5	12.5	2.0
1192	Cygnus	20	47	21	+33	25.9	12.0	< 15.5	3.5
1193	Cygnus	20	47	41	+31	46.2	12.9	16.0	3.1
1194	Cygnus	20	50	18	+30	14.0	11.5	13.7	2.2
1195	Cygnus	20	52	5	+33	19.1	13.4	15.3	1.9
1196	Cygnus	20	52	6	+32	23.2	14.1	< 16.5	2.4
1197	Cygnus	20	52	59	+30	56.8	12.5	15.5	3.0
1198	Cygnus	20	53	8	+32	49.6	13.0	15.2	2.2
1199	Cygnus	20	59	17	+32	40.0	12.5	13.7	1.2
1200	Cygnus	21	45	8	+29	40.0	13.0	14.4	1.4

EDWARD C. PICKERING.

JANUARY 12, 1906.

HARVARD COLLEGE OBSERVATORY.

CIRCULAR 108.

A SYSTEMATIC STUDY OF FAINT STARS.

As the excellent plan of Professor Kapteyn for studying faint stars is now being discussed by astronomers, it may be well to describe the work of a similar character already in progress at the Harvard College Observatory. This work provides for a study of the photometric magnitudes, photographic magnitudes, positions, distribution, colors, and spectra of faint stars, but does not include the study of their proper motions, parallaxes, and radial motions, on the ground that these quantities are at present beyond our reach. If these can be determined, even approximately, they will add greatly to our present knowledge of the stellar universe.

In 1885, a plan for studying the distribution of the stars was employed in the Harvard Annals, 14, 477. The sky is divided into two equal parts by the Equator, and each of these hemispheres is subdivided into two equal parts by the parallels of declination at 30° . The parallel at $61^\circ 3'$ divides the polar portion into two parts, one of which has three times the area of the other. If then, the polar zones are divided into three equal parts, the adjoining zones into nine, and the equatorial zones into twelve, we have the entire sphere divided into forty-eight parts of exactly equal area, each including about 860 square degrees. The meridians of 0^h , 8^h , and 16^h are common to all the zones, and the sky may thus readily be divided into twelve equal parts. The meridians of the equatorial zones are at intervals of 2^h , of the adjoining zones at intervals of $2^h 40^m$. This method of dividing the sky has been employed, during the last twenty years, in a large part of the studies made here of the distribution of the stars; for instance, in Annals, 23, 158, 165, 235, and 26, 145.

The central portions of these regions, the epoch being 1900, have been used for studying the faint stars. If desired, the number of these regions could be doubled by adding the corners, or quadrupled by also adding the centres of each side. One advantage of using these regions is that we already have so many measures of the light of the stars contained in them. For instance, in the greater part of those in

the northern sky, including the additional regions, we have for stars of the magnitude 9.0 and brighter, in zones 20' wide in declination, the estimate in the Durchmusterung, estimates on two evenings at each of the two observatories taking part in the adjoining Gesellschaft Zones, and four photometric measures with the 4-inch Meridian Photometer on each of two or more nights, with results published in the Annals, 24. For stars of the magnitudes 9.1 to 9.5 in the Durchmusterung, we have, besides the estimates in that work, four measures on each of three nights in the case of all stars in zones 10' wide in declination, the centres of the northern regions being on the northern edge, and the southern on the southern edge of each zone. These photometric measures are completed, and are in course of publication in Volume 54 of the Annals.

Sequences have also been selected in regions 1° square, having centres at the centres of the regions 30° square, described above. All stars of the magnitude 7.5 and brighter, according to the Durchmusterung, and all of the magnitude 7.0 and brighter, according to the Argentine General Catalogue, have been measured with the 4-inch Meridian Photometer, and the results published in the Annals, 45 and 46. Their distribution has been discussed in Volume 48, No. 5. For the fainter stars, ten were selected from the Durchmusterung, carrying forward the places to 1900. In general, two stars in each northern sequence were between the magnitudes 7.8 and 8.2, two between 8.3 and 8.7, two between 8.8 and 9.2, one of magnitude 9.3, one of 9.4, and two of 9.5. In the southern sequences, two of the last four stars were of magnitude 9.3 to 9.7 and two of magnitude 9.8 to 10.0. Besides these, five other stars, from the tenth to the thirteenth magnitude, have been selected in each region. All of the stars in 33 of the 36 sequences, in declinations $+75^\circ$, $+45^\circ$, $+15^\circ$, and -15° , have been selected, and each of the stars, nearly five hundred in number, have been measured four times on three nights with the 12-inch Meridian Photometer. The scale is thus extended to the faintest stars visible with that instrument. It is intended to extend these sequences to the faintest stars visible, as soon as the 60-inch Common Telescope is ready for use. The stars at -45° and -75° , have not yet been measured.

Various investigations have been undertaken here to determine the photographic magnitudes of the stars. Measures have been made of the relative brightness of out of focus images of seven thousand stars, including all of those of about the seventh magnitude and brighter, north of declination -10° . In a second investigation, one of the faintest Durchmusterung stars in each square degree is selected, measured, and compared with faint images of all the bright stars on the plate. This work is nearly completed for the region extending from the equator to declination

+ 30°. Nearly eleven thousand faint stars have thus been measured and compared with about twenty thousand faint images of bright stars.

It now becomes a matter of the greatest importance to determine the absolute magnitudes of these stars. For this purpose a series of photographs have been taken with the 8-inch Draper telescope, having successive exposures of equal length, first on the Pole, and then on the centre of one of the regions 30° square. The second exposure is repeated, moving the telescope a little in declination. Two adjacent images are formed of each star, which are thus readily distinguished from the polar stars. These photographs, which were begun in 1901, are now nearly completed. They are taken only at the times that the regions are at nearly the same altitude, in other words at the height of the Pole, and only on nights which are particularly clear and free from clouds. Similar photographs have been taken of stars out of focus. Several other methods have also been used to secure uniformity of scale. Photographs of all the southern regions, and of a part of the northern regions, have been taken with the 24-inch Bruce Telescope, with exposures of two hours. As exposures of ten minutes with this instrument show fainter stars than those given in the charts of the Astrophotographic Congress, much fainter stars should thus be shown, including stars of about the brightness of Phoebe. It is hoped that still fainter stars may be photographed with the two 24-inch Reflectors of this Observatory. Photo-engravings covering half a degree square, from plates taken with these instruments, should be printed on a scale of $20'' = 0.1$ cm.

The spectra of stars as faint as the eleventh magnitude are obtained with the 8-inch Draper and Bache Telescopes, using objective prisms of small angle. It is expected that the spectra of much fainter stars can be photographed with the 24-inch reflectors using the method first tried here in 1893, and later employed with success at the Lick Observatory. Convex and concave lenses of equal curvature are interposed in the cone of rays, and so placed that between them the rays shall be parallel. A prism of small angle inserted between the lenses will give a spectrum of any desired dispersion. With a large refractor, the chromatic aberration is so great that good results cannot be obtained with it when the dispersion is small. This difficulty is remedied with reflectors, and it is proposed to photograph in this way each of the regions described above, and to classify all the spectra in the regions 1° square.

The spectra of much fainter stars may be studied by following the stars precisely, so that the spectra appear as narrow lines. A photograph, I 26274, taken on an isochromatic plate with the 8-inch Draper Telescope, on December 20, 1900, shows about 110 stars within 1° of the North Pole. The spectrum of comparison star *k*, magnitude 13.3, shows distinctly, and can be classified. It is of the first type. The

blue portions of the spectra appear as narrow lines separated by small intervals from the yellow portions, which appear as faint dots somewhat out of focus. The relative intensities of the lines and dots indicate, in general, the class of spectrum. When the spectrum is of the first type, the line is several times as intense as the dot, when of the second, they are more nearly equal, and in some cases, probably for stars of the third and fourth types, the dot is the more intense of the two. While the intensity of the lines cannot well be compared with that of the dots, each can be arranged in a sequence separately, and in this way it is expected that both photometric and photographic magnitudes can be determined, even of very faint stars. With the reflectors, not only can fainter spectra be photographed, but the dots and lines can perhaps be compared directly, since the focus will be the same for both.

Another method, which promises better results, is to photograph the stars through a yellow screen on an isochromatic plate. The relative magnitudes are then nearly the same as those observed by the eye, and the total number of any given brightness is much more readily determined. A comparison with photographs taken in the usual way furnishes a quantitative measure of the colors. Stars as faint as the twelfth magnitude can thus be measured.

During the last five years, a large part of these regions have been photographed with the 8-inch telescopes with exposures of 60^m, in focus and out of focus, and with exposures of 10^m having a photograph of the Pole superposed. Also, spectrum plates have been taken with 60^m exposure and small dispersion. With the 24-inch Bruce Telescope, the greater portion of the charts, with exposures of 120^m, have been made, as stated above.

It now becomes a question whether it is worth while to continue this work, in view of the much more extensive plan of Kapteyn. So large a part of it, however, has been accomplished, that probably it is best to complete at least certain portions of it, as the results will doubtless suggest better methods of carrying out the larger scheme.

EDWARD C. PICKERING.

HARVARD COLLEGE OBSERVATORY.

CIRCULAR 109.

OBSERVATIONS OF PHOEBE DURING 1905.

FOUR observations of Phoebe in May, 1905, are given in Circular 102. Since then, two or more photographs have been taken each month, and the results of all are given in Table I. The first four lines, therefore, repeat those given in Circular 102. The successive columns give the designation of the plate, the date, the Greenwich Mean Time of the middle of the exposure, the length of the exposure, the distance of Phoebe from Saturn, the difference in declination, and the position angle computed from the last two quantities. The measures were made by Mr. E. S. Manson. The last two columns give the observed minus the computed distance and declination, using the ephemeris contained in the Annals 53, 141. On Plate A 7546, the image of Phoebe has not yet been found, and owing to its approach to the Sun no more plates will be obtained until the next opposition.

TABLE I.
POSITIONS OF PHOEBE. 1905.

Plate.	Date.		G. M. T.		Exp.	Distance.	Difference in Declination.	P. A.	Distance.	Declination.
			<i>h.</i>	<i>m.</i>						
A 7300	May	9	21	3	112	10.6	+ 5.8	56.8	-0.4	-0.5
A 7303	"	10	20	40	120	11.0	+ 6.3	54.4	-0.3	-0.1
A 7307	"	12	20	49	120	11.6	+ 6.4	57.1	-0.4	-0.4
A 7308	"	13	20	48	145	12.0	+ 6.6	56.6	-0.3	-0.3
A 7343	June	9	19	39	120	20.8	+ 9.2	63.8	0.0	-0.8
A 7344	"	10	19	9	120	21.2	+ 9.7	62.8	+0.1	-0.4
A 7392	July	7	17	36	118	28.1	+12.0	64.7	-0.2	-0.6
A 7397	"	8	17	10	120	28.4	+12.3	64.3	-0.1	-0.3
A 7430	August	7	20	21	120	34.2	+13.3	67.1	0.0	-0.9
A 7432	"	9	20	23	120	34.4	+13.2	67.4	0.0	-1.0
A 7433	"	10	20	24	90	34.6	+13.3	67.4	0.0	-0.9
A 7453	September	1	13	57	120	36.3	+13.7	69.4	-0.3	-0.7
A 7455	"	5	18	42	100	36.4	+13.9	69.2	-0.4	-0.4
A 7509	October	21	15	0	120	34.6	+11.2	71.1	-0.1	-1.1
A 7510	"	24	14	36	93	34.1	+10.9	71.4	-0.2	-1.2
A 7518	November	16	14	1	120	29.8	+ 9.8	70.8	-0.4	-0.4
A 7521	"	17	14	10	120	29.8	+ 9.4	71.6	-0.2	-0.7
A 7546	December	14	13	14	97	..	..	..	..	..

On June 9 and 10, the distances were recorded 21'.8 and 22'.2. A re-examination of the photographs shows that the measures were in error by 1'.

To determine the accidental errors of these and of the earlier observations, a comparison has been made of these residuals, and of those in Annals 53, 136. It may be assumed that the error in the ephemeris will not change perceptibly during short intervals. Accordingly, when photographs were taken within three days of each other, the means of the differences in the successive residuals have been taken. Each of these differences is the combined error of observation of two measures, and must therefore be multiplied by 0.707 to give the average deviation of one measure. Table II gives, for each year and for all, the number of pairs of observations compared, and the average deviation of a single measure, expressed in seconds of arc. The results for 1905 are derived from the distances and differences in declination, those of the other years, from the longitudes and latitudes, but the difference in the methods will not sensibly affect the results. As all the distances were determined by means of a scale divided into millimetres and estimated to tenths, and as one tenth is equal to 6", the agreement is probably as good as could be expected. Owing to the difficulty of orienting the photograph exactly, it was thought that the errors in distance would be smaller than those in latitude or position angle. This does not seem to be the case, as both are sensibly equal. As the systematic errors of the best ephemeris yet published appear to exceed a minute, and the errors of measurement are only about a tenth of this amount, more precise measures do not seem to be important. In many cases, the images are so faint that the principal errors are due to difficulty in seeing the object, and much greater accuracy would not be secured by repeating micrometric measures indefinitely. In some cases, it is also doubtful whether the object could be seen at all, if viewed through a compound microscope of the usual form. The same remark applies to the images at first measured and afterwards rejected. There was no way of deciding whether the object was really the satellite but to measure it and compare with the ephemeris. The large residuals are therefore not due to errors of measurement, but merely show that with such faint images the real object can only be distinguished by its position and not by its appearance.

TABLE II.
AVERAGE DEVIATIONS.

Year.	No.	A. D.	A. D.
1898	5	12	13
1899	1	1	1
1900	12	5	7
1902	5	22	13
1904	19	3	3
1905	10	4	10
All. . .	52	8	8

EDWARD C. PICKERING.

HARVARD COLLEGE OBSERVATORY.

CIRCULAR 110.

DETERMINATION OF RADIAL MOTIONS BY OBJECTIVE PRISMS.

IN Harvard Circular 13, a method is described for determining the radial motion of stars from spectra obtained with objective prisms. As this method has recently been criticized, it may be well to describe some recent results obtained here, with the Draper telescopes. A photograph is taken in the usual way, the prism is then turned 180° , and a second exposure is given on the same plate. It is not necessary or advisable to use two plates, as recommended in Circular 13. It is often more convenient to reverse the telescope, instead of turning the prism. In the latter case, the plate must also be turned 180° . The second images should be brought side by side with the first, and as near together as possible. It may be better to place the spectra end to end. They may be brought into any desired position by the aid of a ground glass screen, or more precisely by an eyepiece with cross-hairs. Were there no errors, it would only be necessary to measure the distance apart of the corresponding lines of each pair of spectra. Each star whose radial motion was known, would serve to determine the constant distance apart of the lines. The differences in distance, converted into wave lengths, would give the required motions of the other stars. The motions of the Sun and Earth are eliminated, since they are the same for all. The principal sources of error, such as those due to the distortion of the lens and changes of temperature, are radial, and may be determined, using both coördinates of the lines in all the spectra. Changes in the differential refraction may be reduced, if desired, by turning the prism so that the spectra shall be horizontal, instead of vertical.

Figure 1 was obtained from a contact print of a negative representing the Pleiades. It was taken on January 29, 1906, with the 11-inch Draper Telescope. The scale is $52''.6 = 0.1$ cm., and the exposures were 37^m and 30^m , respectively. These conditions are by no means ideal, but the dispersion is such, for the central portions of the spectra, that $1''$ corresponds to an approach or recession of the star of about 70 km. in each spectrum. Since double the motion is measured, if positions can be determined with the accuracy of $\pm 0''.1$, which many astronomers claim is not a high degree of precision for determining star places, the corresponding probable error in the motion would be ± 3.5 km. About a dozen stars could be measured

on this photograph, the brightest, η Tauri, having a magnitude of 3.0, and the faintest, 6.0. In this photograph the images are some distance apart. It is intended to illustrate the method, but not for actual measurement.



FIG. 1.

Another photograph, taken with the 8-inch Draper Telescope on January 29, 1906, with exposures of 20^m , covers a region 10° square, with the Pleiades as a centre. The dispersion is about one third of that in Figure 1, but as the scale is also about one third, the definition is much better, and measures might have nearly the same degree of precision. Much fainter stars are shown on the latter plate, lines being clearly defined in stars of the eighth magnitude. For this reason, and owing to the extent of the region covered, the number of stars measurable exceeds a hundred, but many of these could probably only be used to determine the corrections, since the distortion is large near the edges of the plate, owing to the distance from the centre.

EDWARD C. PICKERING.

FEBRUARY 9, 1906.

HARVARD COLLEGE OBSERVATORY.

CIRCULAR 111.

STARS HAVING PECULIAR SPECTRA. 13 NEW VARIABLE STARS.

THE examination of the later photographs of the Henry Draper Memorial, by Mrs. Fleming, has led to the discovery of a number of variable stars and other objects having peculiar spectra. A list of these is given in Table I, together with two additional variables found by the examination of chart plates, one by Miss E. F. Leland and one by Miss S. E. Breslin. The constellation and number in the Durchmusterung are given in the first two columns. The approximate right ascension and declination for 1900 and the catalogue magnitude, except in the case of variable stars, are given in the third, fourth, and fifth columns. The catalogue designations are taken from the Bonn Durchmusterung, except in the case of α 59° 233, which is taken from the Cape Photographic Durchmusterung. The class of spectrum and a brief description of the object are given in the sixth and seventh columns. Each of the new variables has been confirmed independently by Miss L. D. Wells, unless otherwise specified. Additional information regarding these objects is given in the remarks following the table. In the case of new variable stars, the right ascension is followed by the designation described in the Annals, 48, 93, which gives the approximate position, and also the designation described in the Annals, 53, No. 7, which indicates the number in the series of variables found at Harvard. This last number is also given in the table, for convenience of future reference.

A photograph of the variable star, R Cygni, taken with the 8-inch Draper Telescope on November 19, 1890, shows the spectrum of this star as Class Md, having the hydrogen lines H γ and H δ bright. On a photograph taken with the same instrument, on December 7, 1904, the spectrum of this star appears to be of the fourth type, closely resembling Class Na, and shows no trace of bright hydrogen lines.

TABLE I.
PECULIAR SPECTRA.

Constellation.	DM. No.	R. A. 1900.		Dec. 1900.		Magn.	Spectrum.	Description.
		<i>h.</i>	<i>m.</i>	<i>°</i>	<i>'</i>			
Cassiopeia	....	1	32.4	+57	39	..	Pec.	Bright lines. Type V.
Horologium	-59° 233	2	45.1	-59	28	..	Me 5 d	Variable. H 1201.
Orion	+1° 1005	5	19.6	+1	45	5.0	B Pec.	H β bright.
Auriga	R	5	48.9	+46	6	..	Pec.	Bright lines. Gaseous Neb.
Gemini	+21° 1609	7	23.3	+21	7	..	Pec.	Type IV.
Sextans	....	10	29.9	+0	11	..	..	Variable. H 1202.
Crater	-6° 3469	11	47.6	-7	3	..	Me 5 d	Variable. H 1203.
Corona	....	15	45.2	+36	35	..	Md	Variable. H 1204.
Draco	+54° 1925	17	55.6	+54	41	..	Md	Variable. H 1205.
Sagitta	....	19	15.0	+17	2	..	Md?	Variable. H 1206.
Sagitta	....	19	15.4	+17	5	..	..	Variable. H 1207.
Cygnus	....	19	23.3	+47	9	..	Pec.	Bright lines. Type V.
Aquila	+12° 4228	20	2.3	+12	39	..	Md	Variable. H 1208.
Cygnus	+36° 3907	20	5.8	+36	33	5.5	B Pec.	H β bright.
Cygnus	....	20	14.7	+34	3	..	Md	Variable. H 1209.
Cygnus	....	20	24.7	+38	17	..	Pec.	Bright lines. Type V.
Pegasus	R	22	1.5	+33	1	..	..	Variable. H 1210.
Pegasus	R	22	1.5	+33	1	..	Md	Variable. H 1211.
Pegasus	+11° 4784	22	16.6	+11	42	5.5	B Pec.	H β bright.
Lacerta	....	22	41.8	+54	33	..	Na	Type IV.
Lacerta	+53° 3033	22	51.9	+53	41	9.1	Na	Type IV.
Cassiopeia	+59° 2683	23	10.8	+59	55	9.0	Pec.	Bright lines. Type V.
Andromeda	+34° 4974	23	33.8	+35	13	..	Na	Type IV. Variable. H 1212.
Andromeda	+42° 4827	23	59.5	+43	0	..	Na	Variable. H 1213.

REMARKS.

- h. m.*
 1 32.4. Galactic longitude, 96° 59'. Galactic latitude, -3° 38'.
 2 45.1. *024550* = H 1201. An examination of this star on eight chart plates, taken between September 27, 1895, and December 2, 1902, shows a variation of about 1.3 magnitudes. Estimates from these plates give the approximate limits, 8.1 to 9.4.
 5 19.6. H γ is also visible as a fine bright line superposed on a faint dark band.
 5 48.9. Galactic longitude, 133°. Galactic latitude, +12°. Assuming an error of +2'.8 in declination in the Durchmusterung, this object identifies as +46° 1067, magn. 9.5. The position given is that of the object on the photograph. No evidence of proper motion is shown from a comparison of plates taken on December 29, 1890, and January 16, 1901.

- h. m.*
 7 23.3. This object is in N. G. C. 2392, or identical with it. N. G. C. 2392 was found to have a continuous spectrum, with three bright lines, by Winlock and Peirce, on January 7, 1869. *Annals*, **13**, 68. It was also found to be gaseous in 1872, by d'Arrest. *Astron. Nach.*, **79**, 193. Photographs taken with the 8-inch Draper Telescope, on November 21, 1900, and November 27, 1905, show no trace of the bright lines characteristic of gaseous nebulae, but that the spectrum resembles the fourth type. The images on chart plates, however, are hazy as compared with those of adjacent stars, and the image on a photograph taken with the Bruce Telescope on April 16, 1904, shows distinct nebulosity, especially on the preceding and southern edges.
 10 29.9. 102900 = H 1202. Discovered by Miss E. F. Leland, by superposition of chart plates, and confirmed

- h. m.*
by Mrs. Fleming. An examination of this star on five chart plates, taken between April 24, 1891, and February 11, 1905, shows a variation of about 1.6 magnitudes. Estimates from these plates give the approximate limits 8.9 to 10.5.
- 11 47.6. 114707 = H 1203. An examination of this star on twenty-two chart plates, taken between May 11, 1891, and March 6, 1905, shows a variation of about 1.0 magnitude. Estimates from these plates give the approximate limits, 8.2 to 9.2.
- 15 45.2. 154536 = H 1204. An examination of this star on ten chart plates, taken between July 23, 1890, and May 21, 1903, shows a variation of about 3.0 magnitudes. Estimates from these plates give the approximate limits, 8.3 to 11.5.
- 17 55.6. 175554 = H 1205. An examination of this star on forty-seven chart plates, taken between August 17, 1892, and July 12, 1905, shows a variation of at least 0.6 magnitude.
- 19 15.0. 191517a = H 1206. An examination of this star on ten chart plates, taken between August 19, 1896, and October 15, 1900, shows a variation of at least 2.8 magnitudes. Estimates from these plates give the approximate limits, 8.7 to <11.5.
- 19 15.4. 191517b = H 1207. This star was selected as comparison star "c" for 191517a. In observing the latter star, it was found by Miss S. E. Breslin to be brighter than the comparison star "n" on a plate taken on March 26, 1903. An examination of this star, by Mrs. Fleming, on ten chart plates, taken between May 1, 1900, and March 26, 1903, shows a variation of at least 0.7 magnitude. Estimates from these plates give the approximate limits 12.2 to 12.9.
- 19 23.3. Galactic longitude, $46^{\circ} 38'$. Galactic latitude, $+13^{\circ} 23'$.
- 20 2.3. 200212 = H 1208. An examination of this star on four chart plates, taken between September 18, 1892, and September 9, 1901, shows a variation of at least 1.7 magnitudes. Estimates from these plates give the approximate limits 9.5 to <11.2.
- h. m.*
20 5.8. The hydrogen line H β appears as a fine bright line centrally superposed on the dark line H β , on plates taken with the 11-inch Draper Telescope on July 4 and November 4, 1905.
- 20 14.7. 201434 = H 1209. An examination of this star on five chart plates, taken between September 9, 1893, and May 23, 1899, shows a variation of about 2.6 magnitudes. Estimates from these plates give the approximate limits, 9.9 to 12.5.
- 20 24.7. Galactic longitude, $45^{\circ} 12'$. Galactic latitude, $-0^{\circ} 51'$.
- 22 1.5. 220133a = H 1210. The preceding and southern of two stars, $40''$ apart, both of which are variable, and either of which might be identified as +32 $^{\circ}$ 4335, magnitude 9.5. An examination of this star on sixteen chart plates, taken between December 22, 1890, and August 31, 1902, shows a variation of about 0.6 magnitude. Estimates from these plates give the approximate limits, 10.0 to 10.6.
- 22 1.5. 220133b = H 1211. See 220133a. An examination of this star on nine chart plates, taken between December 22, 1890, and November 23, 1900, shows a variation of about 2.4 magnitudes. Estimates from these plates give the approximate limits, 10.0 to 12.4.
- 22 51.9. Near the border of Andromeda.
- 23 10.8. Galactic longitude, $79^{\circ} 2'$. Galactic latitude, $-0^{\circ} 11'$.
- 23 33.8. 233335 = H 1212. An examination of this star on five chart plates, taken between September 24, 1890, and November 29, 1899, shows a variation of more than 2.3 magnitudes. Estimates from these plates give the approximate limits, 8.2 to <10.5.
- 23 59.5. 235943 = H 1213. Suspected of variability by Espin. *Astron. Nach.*, **137**, 373, and *A. J.*, **16**, 171. Discovered here, independently, from its photographic spectrum. An examination of ten chart plates, taken between October 8, 1891, and November 25, 1903, shows a variation of about 1.5 magnitudes. Estimates from these plates give the approximate limits, 8.3 to 9.8.

SPECTRA OF KNOWN VARIABLES.

The spectra of a number of known variables have also been determined from Draper photographs, and are given in Table II. This contains those classified since Circular 98 was issued, and therefore includes a few already mentioned in the Sixtieth Annual Report of the Director. They are reprinted here for convenience of reference. The first column contains the designation, and the second, the name of the variable. The third column gives the class of spectrum.

A photograph, A 6911, of the region whose centre is in R. A. = $20^h 45^m$, Dec. = $+30^{\circ} 6'$, was taken with the 24-inch Bruce Telescope, on September 2, 1904.

TABLE II.
SPECTRA OF KNOWN VARIABLES.

Desig.	Name	Spectrum.	Desig.	Name.	Spectrum.	Desig.	Name.	Spectrum.
004533	RR Androm.	Md 543	190967	U Draconis	Md?	210812	R Equulei	Md 5
042215	W Tauri	Mb	191350	TZ Cygni	Mc	210903	RR Aquarii	Md 4
063558	S Lyncis	Md 8	194348	TU Cygni	Md 6	220412	T Pegasi	Md 9
133273	T Ursae Minoris	Md 6	195849	Z Cygni	Md 6 Pec.	220714	RS Pegasi	Md 9, 8, 8
153378	S Ursae Minoris	Md 7	200647	SV Cygni	Na	233956	Z Cassiopeiae	Md 7
161138	W Coronae	Md 4						

REMARKS.

042215. The spectrum of this star is given as F? in the Provisional Catalogue of Variable Stars, Annals **48**, No. 3. Plate I, 33567, taken on October 25, 1905, shows the spectrum of this star as Class Mb.
153378. The spectrum of this star is given as Mc 5 d in the Provisional Catalogue of Variable Stars, Annals **48**, No. 3. Plate I, 33601, taken on November 1, 1905, shows the spectrum of this star as Class Md 7.
195849. The spectrum of this star is given as Mc? in the Provisional Catalogue of Variable Stars, Annals **48**, No. 3. Plate I, 33706, taken on November 27, 1905, shows the spectrum of this star as Class Md 6.

with an exposure of 240^m. It shows the entire region containing the nebulae N.G.C. 6960 and N.G.C. 6992. From an examination of this plate, Mrs. Fleming found that the northern and perhaps the southern ends of these nebulae are connected by faint nebulosity forming an irregular oval. A large triangular wisp of nebulosity extends southward, from the north preceding portion of this oval, and is much more conspicuous than the neighboring nebulae, N.G.C. 6974 and N.G.C. 6979.

EDWARD C. PICKERING.

FEBRUARY 16, 1906.

HARVARD COLLEGE OBSERVATORY.

CIRCULAR 112.

VARIABLE STARS OF LONG PERIOD.

ATTENTION has frequently been called in the publications of this Observatory to the importance of continuous observations of variable stars of long period. These objects are also especially suitable for observation by amateurs provided only with small telescopes, and unable to devote much of their time and energy to Astronomy. Announcements are frequently made by unskilled observers of the variability of bright stars, whose changes are not real, but only due to errors of observation. Useful observations of such objects can, in general, only be made by experienced observers, with photometers in which adjacent stars are compared directly, and in which consequently the accidental errors are small. In like manner, a large part of the time is wasted which is spent by unskilled observers in watching variables of short period, or those of the Algol type. For these objects, since the variations in light appear to be regular, accurate photometric measures should be made once for all, and the slight variations, if any, in the periods should later be determined in the same way from time to time. The large accidental errors of ordinary observers render their work on such objects of little or no value. On the other hand, many of the variable stars of long period have so large a range, amounting to several magnitudes, that moderate errors of observation will not sensibly affect the form of the light curve. Thus, an error of half a magnitude will not be serious if the entire change is five magnitudes, while in the case of variables of short period in which the range is only one magnitude, it will render the observation of little value.

In Harvard Annals, 48, No. 3, Miss Cannon has published A Provisional Catalogue of Variable Stars, including all stars known to be variable at the close of 1902. Circular 77, First Supplement to Catalogue of Variable Stars, contains additional stars found in 1903, and Annals, 53, No. 7, contains similar results for 1904. A new catalogue, bringing the results up to the present time, is now in the hands of the printer, and, when published, copies will be given to all observers who can make use of it.

A description of a series of maps formed by enlarging three times portions of the charts of the Durchmusterung, 3° square, around 72 variables, is given in Circular 53. Suitable comparison stars are marked on these maps, and these will be found very convenient in observing variable stars when as bright as the tenth magnitude. When fainter, the charts of Father Hagen are almost indispensable, and these are supplemented by enlargements which have been made here of photographs of 175 regions, taken with the 8-inch Draper and Bache telescopes. They show stars of the twelfth or thirteenth magnitude. The scale is $20'' = 0.1$ cm., and 8×10 prints, on thick paper, covering about one degree square, have been made of them. They will be sold at cost, or given to observers qualified to use them.

The method described below is being substituted here for that of Argelander, with extremely satisfactory results. A sequence of comparison stars is selected for each variable, and the photometric magnitude determined as described in Annals, 37. This magnitude, to the nearest tenth, is entered on the photographic charts described above. It is well to omit the decimal point to avoid mistaking it for a star. A discussion of the magnitudes, from the observations extending over fifteen years and contained in Volume 37, shows that the average correction to the magnitudes originally determined, amounts to only ± 0.08 , which is much less than the unavoidable errors in observing the variable, due to color, position, etc., as is seen by comparing the results of different observers on the same night. With a chart thus marked, the observation consists in estimating the magnitude directly by comparing it with a brighter and fainter star. Thus, if found to be distinctly fainter than a star marked 96, or of magnitude 9.6, and brighter than one marked 100, we enter the magnitude of the variable, 9.8, if nearly as bright as the brighter star, 9.7, and if equal to it, 9.6. These estimates are seldom found to differ by more than a tenth of a magnitude from those obtained by Argelander's method. No further reduction of these observations is required, and the light curve may be constructed the next day, using times and magnitudes as coördinates. The observer should never look at the light curve before making the observations, as, if he knows what magnitude is to be expected, his observations will have little value.

There are about four hundred variable stars of long period of the magnitude 9.0 or brighter, at maximum, and having a range of three magnitudes or more. Observations of each of these should be made at least once a month. About three hundred of those north of declination -30° are under observation at Cambridge, and about forty of those south of -30° , at Arequipa. The pressure of other work renders it difficult to follow all of these variables closely, especially in the case of the

southern stars. Several observatories are now taking part in this work, and it is hoped that the number may be increased, especially for stars in the southern hemisphere. It is only necessary that an observer should be provided with a telescope preferably of four inches or more in aperture, and be able to identify faint stars with certainty. The final magnitudes have been determined of a portion only of the southern comparison stars, but for the others Argelander's method can be used. A careful watch of the remarkable and often unexpected changes of a number of stars is an interesting occupation, and the fact that the time is thus usefully expended should induce many observers to undertake it seriously.

EDWARD C. PICKERING.

FEBRUARY 21, 1906.

HARVARD COLLEGE OBSERVATORY.

CIRCULAR 113.

MEASUREMENTS OF LINNÉ DURING TOTAL LUNAR ECLIPSE.

A SERIES of measurements of the diameter of the bright spot around Linné was made by Mr. R. H. Frost during the total Lunar Eclipse of February 8, 1906, with the 13-inch Boyden Telescope, at the Arequipa Station. The recorder was Mr. P. P. Hill. The filar micrometer and method of measurement were the same as those described in the *Annals*, 32, 117. The value of one revolution of the screw was assumed to be $9''.95$. The first four sets were made for the sake of practice, and consisted of ten settings of the movable wire, five to the left and five to the right of a fixed wire, and the spot between them. The remainder of the night's work was made up of sets of six settings, three to the right and three to the left. The observations are corrected for thickness of the movable thread which was .042 of a revolution. The seeing throughout the night was very poor, and at no time was the crater seen distinctly. All the observations before totality were made through varying densities of clouds, but at all times, except in the last set before totality, the spot surrounding Linné was well seen. The sky, just before the shadow left the vicinity of Linné, was completely and heavily clouded, but about five minutes before the time, a rift appeared near the Moon, and five minutes later the sky was perfectly clear, so that the observations after totality were begun at the first possible moment.

In Table I, the Greenwich Mean Time, the diameter of the spot, the average deviation of the settings, and the seeing on a scale of 10, are given in the successive columns. The computed time, when Moon entered penumbra, was $16^h 54^m.1$; when Moon entered shadow, $17^h 57^m.0$; total eclipse began, $18^h 57^m.8$; total eclipse ended, $20^h 36^m.2$; Moon left shadow, $21^h 37^m.0$; Moon left penumbra, $22^h 39^m.9$.

The average deviation of all the settings is $\pm 0''.17$. The observation at $18^h 23^m.9$ was "through thick clouds, very doubtful, too cloudy to continue." It will be seen that the observations in the first and second portions of the table were made before totality, and the third portion after. Also, that the diameter of the spot

TABLE 1.
MICROMETRIC MEASURES.

G. M. T.		Diameter.	A. D.	S.	G. M. T.		Diameter.	A. D.	S.	G. M. T.		Diameter.	A. D.	S.
<i>h.</i>	<i>m.</i>	"	"		<i>h.</i>	<i>m.</i>	"	"		<i>h.</i>	<i>m.</i>	"	"	
13	46.0	3.06	.64	3	17	34.0	2.94	.20	3	21	18.2	4.53	.15	2.5
14	13.0	3.35	.27	3	17	39.7	3.07	.48	3	21	21.3	1.16	.31	2
14	43.9	3.32	.19	4	17	45.5	3.45	.09	3	21	24.0	3.83	.08	2
15	21.6	3.12	.24	4	17	52.9	3.37	.11	3	21	26.9	4.00	.13	2
16	21.1	3.00	.06	4	17	58.9	3.50	.19	3.5	21	30.1	3.75	.21	2
16	29.9	2.61	.17	4	18	5.3	3.34	.15	.	21	32.5	3.37	.30	2
16	35.7	2.77	.24	3	18	8.7	3.61	.24	3.5	21	34.7	3.43	.18	2
16	51.5	2.75	.20	3	18	12.9	3.44	.20	3.5	21	38.1	3.35	.02	1.5
17	6.3	2.77	.17	3	18	19.3	3.74	.17	3	21	42.2	3.13	.13	1.5
17	21.1	3.05	.11	3	18	23.9	4.49	.11	3	21	44.5	3.36	.07	1

began to increase as it passed into the shadow, and rapidly diminished with increasing sunlight. This is in accordance with the theory advanced by Professor W. H. Pickering (Annals, 51, 24), that this phenomenon is due to the formation and melting of hoar frost.

EDWARD C. PICKERING.

MARCH 14, 1906.

HARVARD COLLEGE OBSERVATORY.

CIRCULAR 114.

THE ALGOL VARIABLE, $+41^{\circ} 851$. 041342.

ANNOUNCEMENT is made, in the *Astron. Nach.* 170, 357, that Mr. Sigurd Enebo has discovered that the star, $+41^{\circ} 851$ (erroneously printed $+41^{\circ} 854$), is a variable of the Algol type, having a period of about 13 days. An examination of 301 of the Harvard photographs of this region by Miss E. F. Leland has led to the results described below. Owing to the pressure of other work, nearly half of the plates of this region have not been examined.

To determine the light curve, a sequence of comparison stars was selected. The designation, coördinates, taking the variable as an origin, and the photographic magnitudes are given in the successive columns of Table I. Stars *a*, *b*, and *c*, are $+41^{\circ} 859$, magn. 8.7, $+41^{\circ} 856$, magn. 9.0, and $+41^{\circ} 854$, magn. 9.1, respectively.

TABLE I.
COMPARISON STARS.

Des.	<i>x</i>	<i>y</i>	Magn.	Des.	<i>x</i>	<i>y</i>	Magn.	Des.	<i>x</i>	<i>y</i>	Magn.
a	+1565	-1646	8.84	e	-16	-85	10.61	k	+456	-486	11.68
b	+628	-791	9.16	f	+163	-277	10.76	l	+196	+166	12.03
c	+383	-584	9.71	g	+134	+192	10.78	m	-228	+57	12.45
d	-293	-326	10.23	h	-16	+24	11.26	n	+171	+187	12.75

It will be noticed that stars *e* and *h* are both near the variable, the first south preceding, the second, north following.

The variable is shown to be faint on twenty-one plates which are enumerated in Table II. The designation of the plate is given in the first column. The letters AC indicate that the photograph was taken with the Cooke Anastigmat, and I, with the 8-inch Draper Telescope. The year, month, and day, the Julian Day and fraction, and the photographic magnitude are given in the next three columns. The times of minima are closely represented by the formula, $2,410,000.08 + 13.199 E$. The value of *E* is given in the fifth column, and the phase in the sixth, no correction

being applied for the velocity of light. The residual of the observed from the computed magnitude, obtained by means of Table III, is given in the seventh column.

TABLE II.
OBSERVATIONS NEAR MINIMUM.

Plate.	Y.	M.	D.	J. D.	Magnitude.	E.	Phase.	Residuals.
I 1878	1890	9	25	1636.839	<10.8	124	+ .083	. .
I 1880	1890	9	25	1636.881	< 9.7	"	+ .125	. .
I 5251	1891	12	18	2085.664	11.8	158	+ .142	+ 0.2
I 17179	1897	1	21	3946.665	11.8	299	+ .084	+ 0.1
I 21787	1898	11	25	4619.707	11.7	350	- .023	0.0
AC 1224	1901	2	8	5424.569	10.7	411	- .300	+ 0.1
AC 2203	1902	1	17	5767.647	9.8	437	- .396	- 0.1
AC 2878	1902	10	8	6031.830	<10.8	457	- .193	. .
AC 3108	1902	12	27	6111.646	9.6	463	+ .429	0.0
AC 4035	1903	10	13	6401.769	<10.6	485	+ .174	. .
AC 4106	1903	10	26	6414.778	11.7	486	- .016	0.0
AC 4180	1903	11	8	6427.747	<10.8	487	- .246	. .
AC 4398	1903	12	18	6467.668	11.2	490	+ .078	- 0.5
AC 4573	1904	1	27	6507.595	9.5	493	+ .408	- 0.1
AC 5325	1904	10	3	6757.837	11.3	513	- .131	- 0.4
AC 5377	1904	10	16	6770.747	<10.6	516	- .420	. .
AC 5597	1904	11	25	6810.671	<10.8	517	- .093	. .
AC 5689	1904	12	8	6823.783	11.8	524	- .180	+ 0.2
AC 6153	1905	3	11	6916.615	10.8	536	+ .259	0.0
AC 6601	1905	8	16	7074.835	<10.8	550	+ .191	. .
AC 7291	1906	2	17	7259.542	<10.8	560	+ .012	. .

In all cases in which the variable was not seen, its computed magnitude was fainter than the limit given in the fourth column, except in the case of AC 5377. The image was near the edge of that plate, which was poor, and the identification was difficult. The computed magnitude was 9.8, but a second independent estimate again gave the value fainter than 10.6. Additional estimates of the image on AC 4398 gave the magnitudes 11.4 and 11.5, and an estimate of AC 5325 gave 11.3.

A light curve was drawn, using as coördinates the phases and magnitudes given in the fourth and sixth columns of Table II. Table III gives, in the successive columns, the magnitudes, and the corresponding phases when the light was decreasing and when it was increasing.

An ephemeris for the next three months is given in Table IV.

It will be noticed that, with one exception, this star has a longer period than any as yet discovered. 215543, UZ Cygni, has a period of 31.304 days, and 044880, RS Cephei, has a period of 12.42 days. The proportion of the time during which the star is faint is unusually small, as in other Algol stars whose period is long. In the case of this star, it is about one fifteenth of the entire period, as is also shown by the fact that it was faint on only 21, out of 301 photographs.

TABLE III.

LIGHT CURVE.

Magn.	Decrease.	Increase.
9.5	-.46	+.45
10.0	-.37	+.36
10.5	-.31	+.30
11.0	-.25	+.24
11.5	-.17	+.17

TABLE IV.

EPHEMERIS.

E.	Minimum.				J. D.
	m.	d.	h.	m.	
563	March	29	3	3	7299.127
564	April	11	7	49	7312.326
565	"	24	12	36	7325.525
566	May	7	17	22	7338.724
567	"	20	22	9	7351.923
568	June	3	2	55	7365.122
569	"	16	7	42	7378.321
570	"	29	12	29	7391.520

In this, as in several other Algol variables, it has been shown that when such a star is discovered in any part of the sky, if of the eleventh magnitude or brighter, the collection of photographs at this Observatory is sufficient to indicate not only the period, but the approximate light curve. When the latter is determined more accurately by later observations, it is probable that the early measures of magnitude will give the period with a high degree of precision.

GIACOBINI'S COMET. 1905 e.

In reply to a request by cable, Mr. R. H. Frost has sent the following determination, by Mr. E. S. Manson, Jr., of the position of Giacobini's Comet, 1905 e. after passing perihelion.

1906, February 14^d.519 G.M.T. R.A. = 0^h 20^m 11^s Dec. = -16° 43' 2 (1875).

1906, February 17^d.533 G.M.T. R.A. = 0^h 41^m 36^s Dec. = -14° 21' 8 (1875).

It will be seen that these positions agree closely with the ephemeris of Wedemeyer published in the *Astron. Nach.* 170, 177.

EDWARD C. PICKERING.

MARCH 28, 1906.

HARVARD COLLEGE OBSERVATORY.

CIRCULAR 115.

TWENTY-TWO NEW VARIABLE STARS IN CARINA.

AN interesting feature of the groups of variable stars which have been discovered during the past two years by Miss H. S. Leavitt is their distribution, as well as the large number of these objects. In comparing the number of variables found in different regions, the conditions under which they were discovered must be considered, or the results will be without value from this point of view. The method adopted in this research has been to compare the photographs, superposed as described in Circular 79, carefully but not exhaustively, using a two inch positive eye-piece. The time spent in the examination of a pair of plates, taken with the Bruce Telescope and covering an area of about 42 square degrees, varies from fifteen minutes to two hours, according to the number of stars in the region and the number of suspected variables marked. The ten variables found in Carina and announced in Circular 79 were found, however, in a superficial examination made with a reading glass, so that these results cannot fairly be compared with others in a study of distribution. A second, more thorough examination of the same six plates has been made, therefore, with the result that 22 additional variables have been found, making the total number now known in this region, 39. Of the seven already catalogued, U Carinae and RX Carinae were independently discovered, while the remainder, which include η Carinae, Nova Carinae, and the suspected variable T Carinae, do not show obvious changes on these plates. The examination of additional photographs would doubtless increase the list of variables, but there is no indication of the existence of a large number in proportion to the whole number of stars, estimated as two hundred thousand, which appear on these plates. The new variables are given in Table I, in which the first three columns contain the designation, the Harvard Number, and the number in the Cape Photographic Durchmusterung. The latter is placed in Italics when, owing to precession, the zone number differs from the degree of declination given in the fourth column. The fourth to the eighth columns give the right ascension and the declination for 1900, the brightest and faintest magnitudes observed, and the range.

TABLE I.
NEW VARIABLES IN CARINA.

Desig.	H.	C. P. D.	R. A. 1900.			Dec. 1900.		Br.	Ft.	R.	[Desig.	H.	C. P. D.	R. A. 1900.			Dec. 1900.		Br.	Ft.	R.
			<i>h.</i>	<i>m.</i>	<i>s.</i>	<i>°</i>	<i>'</i>							<i>h.</i>	<i>m.</i>	<i>s.</i>	<i>°</i>	<i>'</i>			
101761	1214	..	10	17	18	-61	14.5	12.8	15.5	2.7	104057b	1225	..	10	40	58	-57	46.3	13.0	13.9	0.9
101860	1215	..	10	18	26	-60	38.6	13.5	14.5	1.0	104460	1226	..	10	44	31	-60	7.7	12.5	13.1	0.6
102458	1216	2234	10	24	38	-58	50.3	8.8	9.6	0.8	104459	1227	..	10	44	54	-59	31.9	13.0	13.9	0.9
103057	1217	..	10	30	49	-57	30.2	13.5	14.0	0.5	104758	1228	2797	10	47	37	-58	51.3	9.2	10.0	0.8
103160	1218	..	10	31	17	-60	11.5	13.6	16.0	2.4	104859	1229	..	10	48	38	-59	59.7	10.6	11.4	0.8
103158	1219	..	10	31	38	-58	35.1	12.0	13.3	1.3	104960	1230	..	10	49	2	-60	8.1	13.6	14.3	0.7
103260	1220	2033	10	32	38	-60	29.5	8.6	9.8	1.2	105158	1231	..	10	51	0	-58	31.3	11.7	13.7	2.0
103261	1221	..	10	32	49	-61	40.4	12.7	13.3	0.6	105461	1232	..	10	54	11	-61	22.9	12.2	12.8	0.6
103358	1222	..	10	33	44	-58	29.3	12.8	13.6	0.8	105458	1233	..	10	54	51	-58	32.8	10.7	13.0	2.3
103560	1223	..	10	35	1	-60	18.6	11.9	14.2	2.3	105657	1234	..	10	56	20	-57	50.7	13.8	14.5	0.7
104057a	1224	3737	10	40	36	-57	2.6	8.0	8.9	0.9	105658	1235	..	10	56	44	-58	15.5	14.0	15.0	1.0

As these stars have been examined only on a sufficient number of plates to confirm their variability, nothing definite is as yet known of the nature of their changes, excepting in the case of H 1232, which is described below.

105461. A NEW ALGOL STAR IN CARINA. H 1232.

The star 105461 was suspected to be a variable of the Algol type, and was examined, accordingly, on 137 photographs. On 16 of these it was found to be fainter than the normal magnitude, 12.25. The observations are satisfied very closely by adopting, for the times of minimum, the formula J. D. 2,410,001.53 + 3^d.30070 E. The comparison stars are given in Table II, the successive columns of which give the designation, the number in the Cape Photographic Durchmusterung, the rectangular coördinates expressed in seconds of arc and referred to the variable as an origin, and the adopted photographic magnitude. The magnitudes of the three Durchmusterung stars are taken directly from that work. They were not used for comparison.

TABLE II.
COMPARISON STARS.

Des.	C. P. D.	<i>x</i>	<i>y</i>	Magn.
.	-61° 1984	-433	-33	9.4
.	-61° 2001	+107	+168	8.8
.	-61° 2003	+163	-134	9.4
a	..	+241	-225	11.81
b	..	+209	-111	12.07
c	..	+205	+9	12.28
d	..	+105	+28	12.78
e	..	+7	+78	13.06
f	..	+164	-30	13.30

The observations on plates taken when the variable was near minimum are given in Table III. The first five columns give the number of the plate, the date, the Greenwich Mean Time corresponding to the middle of the exposure, the Julian Day and decimal following Greenwich Mean Noon, and the observed magnitude. The sixth and seventh columns give the value of E , and the phase found by subtracting the computed time of minimum from the time of the exposure of the plate. A light curve was plotted, using the residuals in the seventh column as abscissas and the magnitudes in the fifth column as ordinates. The residual from this light curve, is given in the last column. The average deviation, as indicated by the residuals, is ± 0.04 magnitudes.

TABLE III.
OBSERVATIONS NEAR MINIMA.

Plate.	Date.			G. M. T.		J. D.	Magnitude.	Epoch.	Phase.	Residuals.
	y.	m.	d.	h.	m.					
B 9472	1893	5	18	14	29	2602.603	12.6	788	+ 0.121	+ 0.05
B 13521	1895	6	3	13	31	3348.563	12.5	1014	+ 0.123	- 0.04
B 15016	"	10	29	20	2	3496.835	12.5	1059	- 0.137	0.00
X 7369	1896	3	16	15	27	3635.644	12.9	1101	+ 0.043	+ 0.11
B 15556	"	4	8	14	35	3658.608	12.7	1108	- 0.098	+ 0.04
B 16219	"	6	10	13	57	3721.581	12.4	1127	+ 0.162	0.00
A 2208	1897	1	30	18	52	3955.786	12.8	1198	+ 0.017	0.00
A 2250	"	4	26	16	2	4041.668	< 12.3	1224	+ 0.081	..
B 19263	"	5	29	14	46	4074.615	12.7?	1234	+ 0.023	- 0.10
B 19265	"	"	29	15	20	" .639	12.8	"	+ 0.042	+ 0.01
B 19668	"	7	1	13	20	4107.556	< 12.3	1244	- 0.045	..
B 19669	"	"	1	13	35	" .566	< 12.3	"	- 0.035	..
B 24734	1900	2	23	16	1	5074.667	< 12.6	1537	- 0.040	..
B 25185	"	4	30	14	11	5140.591	12.5?	1557	- 0.129	- 0.03
B 27332	1901	5	18	13	29	5523.562	12.8	1673	- 0.039	+ 0.05
B 31365	1903	3	9	17	37	6183.734	12.8	1873	- 0.007	0.00

An ephemeris for the next three months is given in Table IV. The successive columns contain the value of E , the Julian Day and decimal following Greenwich Mean Noon, and the corresponding day, hour, and minute.

But for the fact that the period of this variable has been determined, its small range would have caused it to be rejected by the rule of the Committee of the Astronomische Gesellschaft, which has decided to take no account of photographic variations of less than a magnitude. This is of interest in its bearing upon other variables of small range, which have been announced in the course of the present

TABLE IV.

EPHEMERIS.

E	J. D.	Date, 1906.			E	J. D.	Date, 1906.			E	J. D.	Date, 1906.		
		d.	h.	m.			d.	h.	m.			d.	h.	m.
2221	7332.385	May	1	9 14	2231	7365.392	June	3	9 24	2241	7398.399	July	6	9 34
2222	7335.686	"	4	16 27	2232	7368.693	"	6	16 37	2242	7401.699	"	9	16 47
2223	7338.986	"	7	23 40	2233	7371.993	"	9	23 50	2243	7405.000	"	13	0 00
2224	7342.286	"	11	6 53	2234	7375.294	"	13	7 3	2244	7408.301	"	16	7 13
2225	7345.587	"	14	14 6	2235	7378.595	"	16	14 16	2245	7411.601	"	19	14 26
2226	7348.888	"	17	21 19	2236	7381.895	"	19	21 29	2246	7414.902	"	22	21 39
2227	7352.189	"	21	4 32	2237	7385.196	"	23	4 42	2247	7418.203	"	26	4 52
2228	7355.490	"	24	11 45	2238	7388.496	"	26	11 55	2248	7421.504	"	29	12 6
2229	7358.790	"	27	18 58	2239	7391.797	"	29	19 8	2249	7424.804	Aug.	1	19 18
2230	7362.091	"	31	2 11	2240	7395.098	July	3	2 21	2250	7428.105	"	5	2 31

research. They have been discovered under precisely similar conditions, and in every case the proof of real variability has been established before announcement was made. On the other hand, some stars which show much larger apparent fluctuations of light remain unpublished, on the list of suspected variables. It seems to be a mistaken policy to reject any variable merely on account of its small range, especially in the case of photographic observations, which can always readily be revised and confirmed by another observer, and are not subject to many of the sources of error which exist in visual work. A variable of small range may be an object of great interest, like H 1232, and there is always a possibility, when nothing but the fact of variation is yet known, that the range may be greatly increased by additional observations.

Owing to the faintness of these variables, and of those found in groups in other regions, identification from the published positions is difficult. A series of charts is being prepared, therefore, which will be published in an early number of the *Annals*, thus making it possible for other observers to study these objects.

EDWARD C. PICKERING.

MAY 4, 1906.

HARVARD COLLEGE OBSERVATORY.

CIRCULAR 116.

A DURCHMUSTERUNG OF VARIABLE STARS.

THE plan described below for a Durchmusterung of variable stars has been proposed by Professor Solon I. Bailey.

Certain regions of the sky have now been systematically examined for the discovery of variable stars, the number of which has already increased to more than three thousand. Taking into consideration the immense amount of work which is being carried forward in this line at the observatories of Harvard, Heidelberg, Moscow, and elsewhere, the right time appears to have come for concerted action among astronomers, looking toward a systematic examination of the whole sky, in order to determine the number and distribution of all variable stars, to the faintest magnitudes possible. Otherwise there may be needless duplication in the search, and, as a result, unfortunate waste of labor.

The objection may be made that, if the examination is extended to the whole sky, the number of variables will be so great that their careful observation will be impossible. This may be true; but at least we shall be able to study the distribution of the variable stars, and learn what part they play in the construction of the stellar universe. Since all variables will tend to fall into a few well-defined classes, an examination only sufficient for classification will be necessary for the greater part of them, and elaborate researches will need to be extended only to representative types, and to objects of special interest. A Durchmusterung of variable stars, therefore, would be a worthy achievement for the present generation of observers.

While we recognize the eminent service which has been rendered during the last century by visual observers, it is certain that photographic methods now yield vastly greater results for a given expenditure of time. This is especially true for densely crowded and faint stars. For a study of the whole sky, the plates should be taken with a telescope of the form known as a photographic doublet, since this gives good definition over a large area. This plan would leave, nevertheless, extended fields of investigation, for those who have instruments of other forms,

such as the study of clusters, nebulous regions of small extent, and other special objects. This scheme offers to amateur astronomers an opportunity to take part in a research of permanent value. There are a number of suitable instruments in the possession of those in charge of small observatories, or of amateurs, who can give only limited time to astronomical research; but the thorough and systematic examination of even small portions of the sky would have high value, irrespective of the number of variable stars discovered.

It is undesirable at present to divide the sky into definite areas, and to assign them, by means of some variable-star committee, to the different institutions and observers taking part in such a research. The field is so vast that it will probably be sufficient for each observer to indicate the regions which he prefers to examine. If, after all, a certain amount of duplication takes place, it may be useful, as providing a check on the results obtained by different observers.

For a discussion of the distribution of variable stars it seems absolutely essential that all stars, which surely vary, should be included. No variable should be omitted because its range of variation is so small that it seems to be lacking in interest. While the inclusion of doubtful objects is objectionable, the exclusion of any stars which really vary is still more unwise. Also, all stars which appear on the plates, in the regions selected, should be examined, and the published results should include, if possible, not only the variables found, but also the approximate number of the stars examined. Negative results are next in importance to the discovery of new variables. In a discussion of the distribution, a region void of variables would have nearly the same interest as a rich region like the Small Magellanic Cloud, which contains a thousand variables.

It is hoped that exposures of one or better two hours can be used, and photographic telescopes of eight inches, or more, aperture. This may be expected to show stars as faint as the sixteenth magnitude. An examination of several plates of each region is desirable in order to make the search reasonably complete. The variability should also be confirmed by a second observer.

There should be complete freedom for each observer to use such methods of examination, discussion, and publication, as seem best to him.

Various methods for comparing stellar images on different plates have been used with success. In globular clusters, where the stars are too closely packed to make the method of superposing one plate on another seem feasible, all the stars in a small area were arranged in a sequence in order of brightness, and this sequence was kept in mind while successive plates, usually ten in number, were examined. In the Magellanic Clouds and elsewhere, on the Bruce plates, a positive

is made from one negative, on which another negative is superposed, so that bright and dark images of the same stars are seen together. This method is found in practice exceedingly successful and rapid. At some observatories a stereocomparator is employed. Several exposures on the same plate, but taken at different times, may be used. But in order to find variables of long period in this way the exposures should be distributed over several months, at least. When the period is very close to one day, or a submultiple of a day, plates taken at about the same hour on successive nights will fail to show any variation. They must be taken at different hours of the night, or separated by long intervals. Of course, a variable with a period of precisely one day and with a maximum, or minimum, extending throughout the night, would never be discovered by an observer working at a single station. Special methods for detecting variables, such as the observation of bright hydrogen lines in the spectra of stars of the third type, are probably not practicable for such a *Durchmusterung*.

The number of stars in the sky of the sixteenth magnitude and brighter is not accurately known, but may be estimated at fifty millions. The comparison of such a vast number of stars on several plates is indeed so great an undertaking, that at first it seems impossible. By the rapid methods of photography, however, this work is probably not too extensive for the present generation of variable-star observers, provided systematic methods are employed, and duplication is avoided. The photographs made for this purpose, also, will be valuable for other lines of astronomical research.

Should this plan of coöperation meet the approval of astronomers, the Harvard Observatory will be glad to undertake its part.

EDWARD C. PICKERING.

MAY 11, 1906.

HARVARD COLLEGE OBSERVATORY.

CIRCULAR 117.

1839.30. A NEW ALGOL VARIABLE. —30° 16169. II 1236.

IN Harvard Circular 29, a description was given of a new method of discovering variable stars of short period. A plate was exposed in the usual way, and at regular intervals it was moved by a small amount. A series of images was thus formed of each star, which show variations in intensity if the star varied in light. A large number of plates have been taken like those of the Harvard Map of the Sky (Circular 71), except that, instead of a single exposure of 60^m, a dozen or more exposures of 30^m were made. They cover nearly all of the sky, and show stars of the tenth magnitude and brighter. Means are thus provided for discovering all of the variable stars having a maximum magnitude of 10.0 or brighter, a period of half a day or less, and a range of half a magnitude or more. They also doubtless show many variables of the Algol type, and others which change rapidly in a short time. While the proportion of variables thus found is not likely to be large, everyone that is found must be an object of unusual interest. A few of these plates have been examined by Mrs. Fleming, the greater portion have not been studied. One of the first plates examined led to the discovery of an interesting

TABLE I.
COMPARISON STARS.

Des.	C. DM.	R. A. 1875.			Dec. 1875.	M.	Ptg.	Des.	C. DM.	R. A. 1875.			Dec. 1875.	M.	Ptg.		
		<i>h.</i>	<i>m.</i>	<i>s.</i>	<i>°</i>	<i>'</i>				<i>h.</i>	<i>m.</i>	<i>s.</i>	<i>°</i>	<i>'</i>			
Var.	−30° 16169	18	38	4.2	−30	37.2	8.8	Var.	h	−30° 16174	18	38	11.4	−30	55.6	9.4	9.80
a	−30° 16225	18	40	10.1	−30	29.4	7.6	7.54	k	−30° 16199	18	38	56.0	−30	34.8	9.7	10.05
b	−30° 16127	18	36	29.2	−30	31.2	8.4	8.19	l	−30° 16185	18	38	36.1	−30	42.6	10	10.27
c	−30° 16198	18	38	55.8	−30	5.7	9.1	8.37	m	... ..	18	38	41.1	−30	41.4	..	10.95
d	−30° 16168	18	37	59.6	−30	17.9	9.4	8.47	n	−30° 16179	18	38	20.6	−30	41.6	9.7	11.13
e	−30° 16167	18	37	58.6	−30	30.1	9.4	8.92	o	... ..	18	37	59.2	−30	39.2	..	11.28
f	−30° 16140	18	37	1.4	−30	11.9	9.0	8.97	p	... ..	18	38	16.6	−30	37.6	..	11.50
g	−30° 16156	18	37	31.3	−30	36.2	9.4	9.35	q	... ..	18	37	54.4	−30	35.0	..	11.85

TABLE II.
OBSERVATIONS NEAR MINIMA.

Plate.	Date.			G. M. T.		J. D.	Magn.	Period.	Phase.	O—C.
	y.	m.	d.	h.	m.					
B 16288	96	6	12	19	11	3723.799	9.45	1792	−0.06	0.0
B 16640	"	7	3	14	39	3744.610	9.12	1802	−0.02	−0.3
B 22156	98	11	10	12	14	4604.510	9.12	2216	+0.03	−0.3
B 22558	99	4	8	21	2	4753.876	9.35	2288	+0.14	+0.4
B 23500	"	7	17	14	37	4853.609	9.55	2336	−0.10	+0.3
AM 461	00	5	8	17	24	5148.725	9.02	2478	+0.09	−0.2
B 28196	01	8	12	15	3	5609.627	9.22	2700	−0.09	−0.1
AM1043	"	9	6	13	44	5634.572	9.35	2712	−0.07	0.0
AM1073	"	10	1	13	44	5659.572	9.55	2724	+0.01	+0.2
AM1201	02	4	14	19	19	5854.805	9.35	2818	0.00	0.0
AM1406	"	6	28	13	6	5929.546	10.0	2854	−0.02	. .
"	"	"	"	13	35	" .566	10.0	"	0.00	. .
"	"	"	"	14	6	" .587	9.9	"	+0.02	. .
"	"	"	"	14	36	" .608	9.7	"	+0.04	. .
"	"	"	"	15	6	" .629	9.3	"	+0.06	. .
"	"	"	"	15	34	" .649	9.3	"	+0.08	. .
"	"	"	"	16	5	" .670	9.3	"	+0.10	. .
"	"	"	"	16	35	" .691	8.9	"	+0.12	. .
"	"	"	"	17	6	" .712	8.9	"	+0.14	. .
"	"	"	"	17	36	" .733	8.7	"	+0.17	. .
AM1414	"	7	2	16	25	5933.685	9.70	2856	−0.04	+0.3
AM1631	"	10	10	12	28	6033.519	9.22	2904	+0.11	0.0
AM1952	03	5	18	17	6	6253.712	8.82	3010	+0.14	−0.2
AM2129	"	7	15	15	10	6311.632	9.12	3038	−0.09	−0.2
AM2200	"	8	13	15	36	6340.650	9.02	3052	−0.16	+0.1
AM2261	"	9	3	14	57	6361.623	9.25	3062	+0.05	−0.2
B 32627	"	"	3	15	7	" .630	9.35	"	+0.06	+0.1
AM2702	04	6	3	17	23	6635.724	9.55	3194	−0.01	+0.2
AM2873	"	7	23	13	31	6685.563	9.35	3218	−0.01	0.0
AM3050	"	9	19	14	13	6743.592	9.12	3246	−0.13	0.0
AM3436	05	4	2	21	1	6938.876	9.12	3340	−0.08	−0.3
AM3552	"	5	22	19	56	6988.831	9.55	3364	+0.02	+0.2
AM3641	"	6	20	19	18	7017.804	9.12	3378	−0.08	−0.3
AM3695	"	7	7	13	59	7034.583	10.0	3386	+0.08	. .
"	"	"	"	14	29	" .603	10.0	"	+0.10	. .
"	"	"	"	14	59	" .624	9.9	"	+0.12	. .
"	"	"	"	15	29	" .645	9.5	"	+0.14	. .
"	"	"	"	15	59	" .666	9.0	"	+0.16	. .
"	"	"	"	16	29	" .687	8.7	"	+0.13	. .
AM3711	"	"	11	14	55	7038.622	9.70	3388	−0.03	+0.3

variable, RR Lyrae, 192242, described in Harvard Circular 54. From a similar examination of recent plates, Mrs. Fleming finds that the star C. DM. -30° 16169 is a variable of the Algol type. It varies about a magnitude in a period of a little more than two days. The designations, Cordoba Durchmusterung numbers, right ascensions and declinations for 1875, Cordoba magnitudes, and photographic magnitudes of the comparison stars are given in Table I.

From an examination of 324 photographs it appears that the star had nearly its full brightness, magnitude 8.58, on 298 plates. On 26 photographs the star was distinctly below its maximum magnitude. The plate number, date, Greenwich Mean Time, Julian Day, and magnitude are given in the first five columns of Table II. The letters AM and B, in the first column, denote that the instruments used were the Cooke Anastigmat and the Bache telescopes, respectively. The sixth column gives the number of periods, and the seventh the phase, computed by the formula $2410001.980 + 2.07694$. The last column gives the residual in magnitudes, assuming a light curve whose magnitudes for the phases -0.2 , -0.1 , 0.0 , $+0.1$ and $+0.2$, are 8.7, 9.3, 9.4, 9.2, and 8.6, respectively.

Two of these plates, AM 1406 and AM 3695, were taken by the method of multiple images described above. It was from the examination of the last of

TABLE III.
EPHEMERIS OF MINIMA.

E.	J. D.	Minimum.				E.	J. D.	Minimum.			
3540	7354.348	May	23	8	21	3556	7387.579	June	25	13	54
3541	56.425	"	25	10	12	3557	89.656	"	27	15	44
3542	58.501	"	27	12	2	3558	91.733	"	29	17	35
3543	60.578	"	29	13	52	3559	93.809	July	1	19	25
3544	62.655	"	31	15	43	3560	95.886	"	3	21	16
3545	64.732	June	2	17	34	3561	97.963	"	5	23	7
3546	66.809	"	4	19	25	3562	00.040	"	8	0	58
3547	68.886	"	6	21	16	3563	02.117	"	10	2	48
3548	70.963	"	8	23	7	3564	04.194	"	12	4	39
3549	73.040	"	11	0	58	3565	06.271	"	14	6	30
3550	75.117	"	13	2	49	3566	08.348	"	16	8	21
3551	77.194	"	15	4	40	3567	10.425	"	18	10	12
3552	79.271	"	17	6	30	3568	12.502	"	20	12	3
3553	81.348	"	19	8	21	3569	14.579	"	22	13	54
3554	83.425	"	21	10	12	3570	16.656	"	24	15	44
3555	85.502	"	23	12	3	3571	18.733	"	26	17	35

these plates that the variable was discovered. AM 1406 contains 13 exposures of 30 minutes each. On the first the star was not seen; on the last three it had its full brightness. The measure of the image at 5929.733 has been inserted in the table. The other three have been omitted. On AM 3695, the first four images were not seen, and on the last eight the star was at its maximum brightness. The image at 7034.583 was included. The other eleven have been omitted. The images on these plates could not easily be compared with those of the comparison stars. They have therefore been estimated directly on a scale such that the faintest image of this star was called 10.0, and the maximum magnitude, 8.7. This scale is, therefore, unlike that used for the other plates. It will be noticed that these plates indicate a change in phase of about 0.08 day, which would indicate that the period was too short by $0^d.00015 = 13^s$.

An ephemeris of the minima of this star for the next two months is given in Table III. The corresponding values of E, of the Julian Day, and of the calendar date and Greenwich Mean Time, are given in the successive columns.

In Circular 114, it should have been stated that the photographic magnitude at maximum, of Enebo's Algol variable, +41° 851, is 9.1.

EDWARD C. PICKERING.

MAY 20, 1906.

HARVARD COLLEGE OBSERVATORY.

CIRCULAR 118.

OBSERVATIONS OF PHOEBE IN MAY AND JUNE, 1906.

Six photographs of Saturn, showing images of Phoebe, have been obtained with the 24-inch Bruce Telescope at Arequipa. They are given in Table I. in a form which is nearly the same as that contained in Circular 109, for the similar observations of 1905. The designation of the plate, the date, the Greenwich Mean Time of the middle of the exposure, and the duration of the exposure are given in the first four columns. The difference in right ascension, the difference in declination, the distance, and the position angle are given in the fifth, sixth, seventh, and eighth columns. Of these, the sixth and seventh are the measured quantities, the fifth and eighth are derived from them by computation. Computed values for the differences in right ascension and declination were taken from the ephemeris given on the leaf following the Contents in the second edition of the American Ephemeris and Nautical Almanac for 1906, and subtracted from the observed values in the fifth and sixth columns. The residuals are given in the ninth and tenth columns. The measures were made by Mr. E. S. Manson, Jr.

TABLE I.
POSITIONS OF PHOEBE. 1906.

Plate.	Date, 1906.	G. M. T.		Exp.	Difference in R. A.		Difference in Dec.	Distance.	P. A.	O—C, R. A.	O—C, Dec.
		<i>h.</i>	<i>m.</i>		<i>m.</i>	<i>s.</i>				<i>s.</i>	<i>'</i>
A 7674	May 18	21	3	120	—1	34.1	—10.8	25.7	245.0	—0.5	—0.2
A 7676	" 19	21	7	120	—1	33.8	—11.0	25.7	244.7	—0.1	—0.4
A 7745	June 25	19	0	120	—1	26.8	—9.0	23.3	247.3	—1.0	+0.1
A 7754	" 26	18	55	120	—1	26.3	—9.0	23.2	247.2	—1.0	0.0
A 7758	" 27	18	59	120	—1	25.4	—9.0	23.0	247.1	—0.7	0.0
A 7763	" 28	18	53	121	—1	25.0	—9.0	22.9	246.9	—0.8	—0.1

If desired, more precise measures of these photographs can be made. As the uncertainty in each coördinate rarely exceeds $0'.1 = 6''$, it does not seem as if this would be necessary, at least until elements are determined which will represent the earlier positions more closely.

EDWARD C. PICKERING.

AUGUST 19, 1906.

HARVARD COLLEGE OBSERVATORY.

CIRCULAR 119.

OBSERVATIONS OF PHOEBE IN AUGUST AND SEPTEMBER, 1906.

NINE additional photographs of Saturn, showing images of Phoebe, have been obtained with the 24-inch Bruce Telescope at Arequipa. The positions of Phoebe, as determined by these plates, are given in Table I, the form of which is the same as that contained in Circular 118. The designation of the plate, the date, the Greenwich Mean Time of the middle of the exposure, and the duration of the exposure are given in the first four columns. The difference in right ascension, the difference in declination, the distance, and the position angle are given in the fifth, sixth, seventh, and eighth columns. Of these, the sixth and seventh are the measured quantities, the fifth and eighth are derived from them by computation. Computed values for the differences in right ascension and declination were taken from the ephemeris given on the leaf following the Contents in the second edition of the American Ephemeris and Nautical Almanac for 1906, and subtracted from the observed values in the fifth and sixth columns. The residuals are given in the ninth and tenth columns. The measures were made by Mr. E. S. Manson, Jr.

TABLE I.

POSITIONS OF PHOEBE. 1906.

Plate.	Date. 1906.	G. M. T.		Exp.	Difference in R. A.		Distance.	P. A.	O—C. R. A.	O—C. Dec.
		<i>h.</i>	<i>m.</i>	<i>m.</i>	<i>s.</i>	<i>′</i>	<i>′</i>	<i>°</i>	<i>s.</i>	<i>′</i>
A 7993	Aug. 11	15	58	119	− 47.3	− 4.0	12.4	251	− 0.4	− 0.2
A 8000	“ 16	15	27	120	− 42.9	− 3.3	11.1	253	− 1.2	− 0.1
A 8016	“ 19	15	23	105	− 38.4	− 3.0	10.0	253	− 0.8	− 0.2
A 8028	“ 21	20	54	120	− 36.6	− 2.6	9.4	254	− 0.5	− 0.1
A 8037	“ 23	20	41	120	− 35.0	− 2.1	8.9	256	− 1.2	+ 0.1
A 8046	“ 25	17	46	120	− 32.9	− 2.1	8.4	256	− 1.1	− 0.1
A 8090	Sept. 12	15	55	120	− 13.7	+ 0.4	3.4	277	− 2.3	− 0.1
A 8094	“ 13	13	55	120	− 11.5	+ 0.6	2.9	282	− 1.1	0.0
A 8099	“ 17	13	41	120	− 7.0	+ 1.0	2.0	300	− 1.3	− 0.2

EDWARD C. PICKERING.

NOVEMBER 6, 1906.

HARVARD COLLEGE OBSERVATORY.

CIRCULAR 120

THIRTY-ONE NEW VARIABLE STARS.

THE study of the distribution of variable stars by superposing a negative on a positive of a different date, has been continued this fall by Miss Henrietta S. Leavitt, with the following results. Five plates taken with the 24-inch Bruce Telescope, with centres at about R.A. = $3^h 40^m$, Dec. = $+23^\circ.5$, and having exposures of from one to four hours, were examined with the usual care, and only one new variable was discovered. The plates, most of which are of excellent quality, cover a region five degrees square with good definition, and it is estimated that about 150,000 stars were examined. The Pleiades are near the centre of the plates. The single variable discovered is in remarkable contrast with the large numbers found in other regions by the same observer, and announced in recent circulars. The only known variable in this region is 032723, — Tauri, which is near the edge of the plates. Apparently conditions in the vicinity of the Pleiades favor unusual constancy in light, as no stars were even suspected of variability, though there are many suspected variables in the other regions as yet examined in this way.

A plate with the Nebula of Orion in the centre, R.A. = $5^h 30^m$, Dec. = $-5^\circ.5$, exposure 74^m , taken last winter, has been compared with an early plate, with the result that two new variables were found, while seventeen known variables were re-discovered. The method used is not adapted to the discovery of variables in regions where nebulosity is strong, unless the variations are large. Star 053007, in Table I, is in such a region, but it had been previously suspected, and its variation was confirmed by direct comparison of several negatives. The region of the Southern Cross and the "Coal-Sack" has been examined on thirteen plates, three of which have centres at about R.A. = $12^h 20^m$, Dec. = $-62^\circ.5$, and ten have centres at about R.A. = $12^h 50^m$, Dec. = $-62^\circ.5$. Twenty-eight new variables were discovered, and the known variables, 121861, R Crucis, and 131360, — Centauri, were also found.

The new variables are given in Table I, in which the successive columns give the designation, the Harvard number, the constellation, the right ascension and declination for 1900, the brightest magnitude so far observed, and the range. The faintest magnitude so far observed may be found by adding the quantities in the

two last columns. Stars *122964*, *123263*, *125964a*, and *131864* probably have long periods, while the periods of stars *124863*, *125763*, and *125964b* appear to be short.

TABLE 1.
NEW VARIABLE STARS.

Designation.	Harvard No.	Constellation.	R. A. 1900.			Dec. 1900.		Br.	R.
			<i>h.</i>	<i>m.</i>	<i>s.</i>	<i>°</i>	<i>'</i>		
034725	1237	Taurus	3	47	2	+25	14.9	12.0	3.0
052603	1238	Orion	5	26	4	-3	28.0	12.5	0.9
053004	1239	Orion	5	30	44	-4	49.8	14.0	0.6
115763	1240	Crux	11	57	50	-63	10.2	10.8	5.2
120563	1241	Crux	12	5	57	-63	52.7	10.8	2.7
121261	1242	Crux	12	12	18	-61	12.3	13.1	1.1
121860	1243	Crux	12	18	00	-60	2.7	12.5	1.5
122060	1244	Crux	12	20	24	-60	57.2	13.4	3.0
122964	1245	Crux	12	29	8	-64	0.8	12.8	1.7
123263	1246	Crux	12	32	46	-63	48.1	14.2	2.8
123460	1247	Crux	12	34	17	-60	52.2	15.0	1.0
123564	1248	Musca	12	35	19	-64	10.2	14.2	>2.8
124061	1249	Crux	12	40	19	-61	17.2	11.4	0.8
124361	1250	Crux	12	43	36	-61	13.5	15.0	1.0
124564	1251	Musca	12	15	26	-64	55.5	14.0	2.4
124863	1252	Crux	12	48	22	-63	23.4	12.7	1.1
125162	1253	Crux	12	51	15	-62	56.5	14.0	1.3
125262	1254	Centaurus	12	52	6	-62	25.6	10.2	0.7
125564	1255	Musca	12	55	37	-64	5.4	8.5	0.4
125664	1256	Musca	12	56	39	-64	42.6	13.2	2.5
125763	1257	Centaurus	12	57	13	-63	7.5	14.0	3.1
125764	1258	Musca	12	57	23	-64	15.1	13.4	1.2
125860	1259	Centaurus	12	57	58	-60	14.0	11.5	1.5
125964a	1260	Musca	12	59	21	-64	58.6	10.5	1.6
125964b	1261	Musca	12	59	23	-64	45.6	14.7	>2.3
130662	1262	Centaurus	13	6	26	-62	52.0	11.5	1.0
130763	1263	Centaurus	13	7	9	-63	37.1	8.8	1.6
130962	1264	Centaurus	13	9	47	-62	30.7	12.3	1.2
131362	1265	Centaurus	13	13	2	-62	24.1	12.9	1.3
131560	1266	Centaurus	13	15	39	-60	47.1	10.4	4.0
131864	1267	Musca	13	18	16	-64	8.4	10.5	>3.5

REMARKS.

053004. Suspected of variation in 1904.

125162. Probably of the Algol Type.

125262. Probably of the Algol Type.

125564. This star is C.P.D. — 63° 2485. For period, see below.

125664. Follows a pair of fifteenth magnitude stars by 0.2.

130763. This star is C.P.D. — 63° 2632. For period, see below.

131362. Probably of the Algol Type. Has a hazy appearance, and may be double.

131864. Discovered independently from its spectrum, by Mrs. W. P. Fleming, four days after original discovery.

The variable, *130763*, was found to be of the Algol Type, and was observed on 256 plates, of which 27 showed it near minimum brightness. The observed times of minimum are well satisfied by the formula J.D. 2,410,000.35 + 2^d.47871 E. The spectrum is of the class B 8 A. A full discussion of the observations will be published in an early number of the Annals.

The variable, *125564*, was observed on a large number of plates, and has been found to be of especial interest on account of the unusual character of its light curve. It varies only from magnitude 8.5 to 8.9, in a period represented by the formula J.D. 2,410,000.15 + 0^d.93796 E. It was at first thought to be of the Algol Type, but it appears probable that the light is slightly but continuously changing even near maximum, in which case it should be classed as a variable of short period. The observations will be published in the forthcoming number of the Annals mentioned above, but it seems desirable to give here the principal results. The star was difficult to observe, particularly when near maximum, and for this reason was independently measured four times on nearly all of the plates taken with the 1-inch Cooke lens, and on all the plates taken with the 8-inch Bache Telescope when the variable was faint. The errors of observation were thus reduced one-half. The average deviation of a single observation from the mean of four, was ± 0.03 magnitudes. On account of the small range, the phase was computed for each of the plates which were measured four times, 136 in number, although, in the case of Algol variables, this is usually done only for the plates taken near the times of minima. The observations were then arranged in the order of phase, and the means of the phases and magnitudes were taken for each group of five. In Table II, the first column gives the mean phases and the second the mean magnitudes for the successive groups. Six plates are included in the last group, at mean phase

TABLE II.

125564 MEAN PHASES AND MAGNITUDES.

Mean Phase.	Mean Magn.	Res.	Mean Phase.	Mean Magn.	Res.	Mean Phase.	Mean Magn.	Res.	Mean Phase.	Mean Magn.	Res.
-0.448	8.48	01	-0.135	8.58	07	+0.036	8.87	01	+0.276	8.53	01
-0.400	8.52	03	-0.117	8.68	02	+0.056	8.80	05	+0.322	8.51	01
-0.358	8.54	04	-0.088	8.77	01	+0.071	8.81	00	+0.358	8.49	01
-0.307	8.49	02	-0.069	8.87	06	+0.089	8.72	04	+0.383	8.51	02
-0.243	8.53	00	-0.047	8.83	03	+0.115	8.73	03	+0.408	8.48	01
-0.195	8.58	01	-0.028	8.89	00	+0.175	8.61	02	+0.444	8.48	01
-0.158	8.57	04	+0.012	8.87	03	+0.226	8.52	02			

+0.444. These quantities were plotted, using the phases as abscissas and the magnitudes as ordinates, and a smooth curve was drawn through the points thus

TABLE III.
LIGHT CURVE.

Phase.	Magn.
0.00	8.90
0.05	8.86
0.10	8.73
0.15	8.62
0.20	8.56
0.25	8.53
0.30	8.51
0.35	8.50
0.40	8.49
0.45	8.49

given. The residuals from this curve, expressed in hundredths of a magnitude, are given in the third column, negative values being indicated by Italics. The average deviation of a single point is ± 0.02 magnitude, and that of observations on individual plates is ± 0.05 . The coördinates of the light curve are given in Table III. The deviations are large enough to make it uncertain whether it is symmetrical, although this has been assumed.

Ephemerides for the two variables are given in Table IV. In the first half of the table, every thirtieth minimum for six months beginning with the epoch 8080 is given for variable *125564*, and in the second half, every tenth minimum covering the same period and beginning with the epoch 3060 is given for variable *130763*. The successive columns, in each half of the table, give the number of the epoch, the Julian Day and decimal following Greenwich Mean Noon, the date, and the Greenwich Mean Time of minima.

TABLE IV.
EPHEMERIDES FOR VARIABLES *125564* AND *130763*.

Epoch.	J. D.	Date.					Epoch.	J. D.	Date.				
		y.	m.	d.	h.	m.			y.	m.	d.	h.	m.
8080	7578.867	1907	January	2	20	52	3060	7585.203	1907	January	9	4	53
8110	7607.006	"	"	31	0	8	3070	7609.990	"	February	2	23	50
8140	7635.145	"	February	28	3	30	3080	7634.777	"	"	27	18	42
8170	7663.283	"	March	28	6	48	3090	7659.564	"	March	24	13	34
8200	7691.422	"	April	25	10	10	3100	7684.351	"	April	18	8	27
8230	7719.561	"	May	23	13	30	3110	7709.139	"	May	13	3	20
8260	7747.699	"	June	20	16	50	3120	7733.926	"	June	6	22	17
8290	7775.838	"	July	18	20	10	3130	7758.713	"	July	1	17	10

EDWARD C. PICKERING.

NOVEMBER 10, 1906.

HARVARD COLLEGE OBSERVATORY.

CIRCULAR 121.

105853. NOVA VELORUM. II 1268.

DURING an examination of photographs taken with the 1-inch Cooke lens, a new object was found, by Miss Leavitt, in the constellation Vela. It precedes the star C.P.D. — $53^{\circ} 43'00''$, magn. 10.0, by about 2^s , and is north $2''$. Its position for 1900 is, therefore, R.A. = $10^h 58^m 20^s$, Dec. — $53^{\circ} 50'9''$. It follows a fifteenth magnitude star by about 2^s and is south of it $15''$. The Durchmusterung star may be found on the Map of the Sky (Circular 71) in the position No. 50, [146, 101]. Owing to the small scale of these plates, measurements of position and brightness were difficult. The object does not appear on any plate taken before December 5, 1905, but is seen on fourteen plates taken since that date. The latest plate taken before its appearance was AM 3718, July 12, 1905, on which stars as faint as the magnitude 11.5 are clearly seen. All observations on plates taken since that date and including it, are given in Table I, in which the successive columns give the plate number, the date, the length of exposure, the Julian Day, and the magnitude. On Plate AM 4143, there are 17 exposures of from 25 to 30 minutes each.

TABLE I.
OBSERVATIONS OF THE NOVA.

Plate.	Date.			Ex.	J. D.	Magn.	Plate.	Date.			Ex.	J. D.	Magn.
	y.	m.	d.	m.				y.	m.	d.	m.		
AM 3718	1905	7	12	60	7039	<11.5	AM 4185	1906	4	28	60	7329	10.55
AM 4015	"	12	5	62	7185	9.72	AM 4194	"	4	30	60	7331	10.42
AM 4053	1906	1	26	60	7237	9.72	AM 4212	"	5	10	60	7341	10.10
AM 4076	"	1	30	63	7241	9.98	AM 4225	"	5	12	60	7343	10.15
AM 4098	"	2	3	60	7245	9.95	AM 4287	"	6	11	64	7373	10.02
AM 4133	"	3	17	75	7287	9.80	AM 4300	"	6	13	65	7375	9.80
AM 4134	"	3	21	70	7291	9.78	AM 4352	"	6	29	60	7391	11.05
AM 4143	"	3	26	485	7296	9.80	AM 4364	"	7	2	60	7394	<11.2

The number of early plates examined, on which the Nova was not seen and was fainter than the eleventh magnitude, was 127, the numbers taken in successive years being as follows: in 1889 one, 1890 two, 1891 one, 1892 one, 1893 three, 1894 eight, 1895 eleven, 1896 ten, 1897 eighteen, 1898 eleven, 1899 six, 1900 eleven, 1901 ten, 1902 eleven, 1903 seven, 1904 nine, 1905 seven. Two of these plates taken with the 24-inch Bruce Telescope, and two taken with the 8-inch Bache Telescope, show stars at least as faint as the magnitude 15.0, and twenty-five other plates show stars as faint as the magnitude 13.5, but no trace of the Nova could be found on any of them.

The Nova shows considerable fluctuation in light during the period covered by the observations, and it is not impossible that it may again become sufficiently bright for its spectrum to be obtained. Even without such proof, there can be little doubt that the object observed is actually a nova.

EDWARD C. PICKERING.

NOVEMBER 12, 1906.

HARVARD COLLEGE OBSERVATORY.

CIRCULAR 122.

THIRTY-SIX NEW VARIABLE STARS.

IN the course of the study, by Miss Leavitt, of the distribution of variable stars, the majority of the variables discovered have been fainter at maximum than the tenth magnitude. This is owing to the long exposure of the plates, taken with the 24-inch Bruce Telescope, which have been used. Not only is the number of faint stars on these plates very great in proportion to that of stars brighter than the tenth magnitude, but the discovery of variations among the brighter stars is, perhaps, disproportionately small because their images are so large that only striking variations are noticeable. Since the beginning of this work, it has been felt that the plates taken with the 1-inch Cooke lens, which cover a region of the sky 30° square and show stars of the eleventh magnitude and brighter, would furnish a valuable means of discovering the brighter variables. The Map of the Sky, described in Circular 71, is composed of plates belonging to this series. In January, 1905, four of these plates, having centres in R.A. = 16^h , Dec. = -45° , were superposed, as described in Circular 76. The positive used was very dense, and not well suited for the purpose of discovering variables, for which a thin positive is now always used. The six known variables RS Librae, RU Librae, RZ Scorpil, RS Scorpil, RR Scorpil, and RW Scorpil were rediscovered, however, together with the planet Uranus. No new variables were found, and owing to the pressure of other work, the examination of plates belonging to the Map of the Sky was only recently resumed. The region selected was that covered by Plate 50, which has its centre in R.A. = 12^h , Dec. = -60° . The Nebula in Carina and the "Coal-Sack," which had already been examined on Bruce plates of long exposure, with results given in Circulars 79, 115, and 120, are seen on these plates. Six photographs were compared, and 36 new variables were discovered, besides Nova Velorum, announced in Circular 121. The sixteen known variables, S Carinae, RX Carinae, U Carinae, RS Centauri, W Centauri, R Crucis, R Muscae, S Crucis, RV Centauri, 131360, 102458, 103260, 104057a, 104758, 105160, and 125564 were re-discovered.

the last six having been originally found on Bruce plates, and recently announced. In the entire region, within 15° of the centre of the plates, there are twenty-five known variables brighter, at maximum, than the tenth magnitude, omitting η Carinae, the suspected variable T Carinae, Nova (RS) Carinae, Nova Velorum, and RT Carinae which is too much involved in the nebula to be found by this method. The nine variables which might be found on these plates but were not re-discovered, are Z Carinae, Y Carinae, RZ Carinae, S Muscae, T Crucis, U Centauri, 104265, 130656, and 130763. It is believed that an examination of ten good plates of any region, suitably distributed as to time, may be regarded as thorough, though no examination can be exhaustive. It may be considered satisfactory, therefore, that on six plates, 16 out of 25 known variables were re-discovered, while 36 new ones were found. This indicates that there may be from 70 to 80 variable stars in the region, which are brighter at maximum than the tenth magnitude.

In Table I, the first three columns give the designation, the Harvard number and the constellation. The fourth column gives the number in the Cape Photographic Durchmusterung. The fifth and sixth columns give the right ascension and the declination for 1900. The seventh, eighth, and ninth columns give the brightest and faintest magnitudes so far observed, and the range.

Six of the new variables probably belong to the Algol Type. All of these have been measured, but the period of only one star, 121249 — Centauri, has been determined, as it seemed best not to delay their announcement. Results of the measurements, so far as at present known, are given in the Remarks following Table I. It is expected that the observations will be published in the Annals at an early date. Some of these variables may not prove to be of the Algol Type, as was the case with variable 125564, announced in Circular 120, whose light curve resembles that of an Algol variable, but is more nearly akin to the type of β Lyrae. Two new Algol variables, one in Carina and one in Centaurus, were discovered on Bruce plates and announced in Circulars 115 and 120, and three other variables announced in Circular 120 are probably of the same type. The number of variables of the Algol type at present known in this region, therefore, is probably eleven. Many of the new variables have short periods, the most obvious being 092673, 104055, 105863, 110060, 110551, 113966, 120658, 121548, 123559, 124058, 132763, and 133357. The periods of the following stars are probably long: 102557, 102861, 105061, 105364, 113657, 113662, 114161, 114953, 120749, 123753, and 134459.

TABLE I.
NEW VARIABLE STARS.

Designation.	Harvard No.	Constellation.	C. P. D. No.	R. A. 1900.			Dec. 1900.		Bright.	Faint.	Range.
				<i>h.</i>	<i>m.</i>	<i>s.</i>	<i>°</i>	<i>'</i>			
092673	1269	Carina	...	9	26	29	-73	6.3	9.0	<10.0	1.0
101259	1270	Carina	-59° 2007	10	12	30	-59	42.9	9.2	10.3	1.1
101659	1271	Carina	-59° 2059	10	16	56	-59	57.0	9.8	10.5	0.7
102359	1272	Carina	-59° 2135	10	23	14	-59	9.7	9.4	10.3	0.9
102557	1273	Carina	-56° 3425	10	25	26	-57	6.2	8.0	9.0	1.0
102861	1274	Carina	-61° 1705	10	28	30	-61	16.1	8.8	9.8	1.0
104055	1275	Vela	-55° 3800	10	40	54	-55	45.8	8.4	9.4	1.0
105061	1276	Carina	-61° 1955	10	50	12	-61	30.5	9.0	9.7	0.7
105364	1277	Carina	-64° 1564	10	53	22	-64	35.9	9.0	10.0	1.0
105863	1278	Carina	-63° 1798	10	58	19	-63	43.4	9.3	10.0	0.7
110060	1279	Carina	-60° 2497	11	0	7	-60	26.3	8.8	9.6	0.8
110558	1280	Carina	-58° 3216	11	5	23	-58	17.8	7.	8.	1.
110551	1281	Centaurus	-51° 3909	11	5	29	-51	56.9	9.8	10.7	0.9
110647	1282	Centaurus	-47° 4810	11	6	34	-47	18.0	8.7	9.6	0.9
112650	1283	Centaurus	-50° 4289	11	26	31	-50	53.2	9.2	10.2	1.0
113547	1284	Centaurus	-47° 5118	11	34	57	-47	24.5	9.1	10.0	0.9
113657	1285	Centaurus	...	11	36	10	-57	6.3	9.8	13.0	3.2
113662	1286	Centaurus	-62° 2223	11	36	14	-62	8.4	8.7	9.5	0.8
113966	1287	Musca	-66° 1637	11	39	49	-66	45.0	8.7	9.7	1.0
114161	1288	Centaurus	...	11	41	42	-61	20.2	10.6	<11.4	0.8
114360	1289	Centaurus	-59° 3809	11	43	5	-60	0.5	8.8	9.8	1.0
114764	1290	Musca	-64° 1725	11	47	24	-64	50.8	9.4	10.3	0.9
114953	1291	Centaurus	-53° 4824	11	49	8	-53	36.7	9.8	10.5	0.7
120658	1292	Crux	-58° 4151	12	6	42	-58	13.6	8.7	9.3	0.6
120749	1293	Centaurus	-49° 4965	12	7	51	-49	39.0	9.1	10.0	0.9
121249	1294	Centaurus	-49° 5046	12	12	30	-49	10.8	8.8	11.4	2.6
121548	1395	Centaurus	-48° 4730	12	15	52	-48	39.3	8.3	10.2	1.9
123559	1396	Crux	-59° 4388	12	35	41	-59	14.7	8.5	9.4	0.9
123753	1397	Centaurus	-53° 5293	12	37	37	-53	58.8	9.4	<11.0	1.6
124058	1398	Crux	-58° 4490	12	40	32	-58	34.6	8.5	9.0	0.5
130359	1399	Centaurus	-59° 4781	13	3	10	-59	42.9	9.4	10.5	1.1
132763	1300	Centaurus	...	13	27	6	-63	32.4	9.5	10.5	1.0
133357	1301	Centaurus	-56° 5865	13	33	45	-57	6.4	7.6	8.7	1.1
133561	1302	Centaurus	-61° 3912	13	35	3	-61	15.8	9.8	10.8	1.0
134358	1303	Centaurus	-57° 6324	13	43	50	-58	0.3	8.0	8.9	0.9
134459	1304	Centaurus	-59° 5228	13	44	21	-59	54.7	9.7	10.7	1.0

REMARKS.

101259. Probably of the Algol type. Faint on 58 out of 453 plates measured.
101659. A twelfth magnitude star is about 0'.2 north of the variable, and renders observation difficult.
110551. C. DM. -51° 5387. Period short. Measured on 168 plates.
110647. C. DM. -47° 6583. Probably of the Algol type. Faint on 22 out of 276 plates measured.

<i>112650</i> . C. DM. $-50^{\circ} 6082$.	observed exactly at minimum, and the range may be greater than that given in the table.
<i>113547</i> . C. DM. $-47^{\circ} 7032$.	
<i>114360</i> . Probably of the Algol type. Faint on 49 out of 351 plates measured.	<i>121548</i> . C. DM. $-48^{\circ} 7357$. Period short. Measured on 248 plates.
<i>120658</i> . Period short. Measured on 340 plates.	<i>133357</i> . Image often looks nebulous, and sometimes unusually sharp.
<i>120749</i> . C. DM. $-49^{\circ} 6898$.	
<i>121249</i> . C. DM. $-49^{\circ} 6972$. This star is of the Algol type. Times of minima, J. D. $2,410,002.90 + 5^d.21943$ E. Faint on 30 out of 286 plates measured. Has not been	<i>133561</i> . Probably of the Algol type. Faint on 30 out of 233 plates measured.
	<i>134358</i> . Perhaps of the Algol type. Faint on 58 out of 304 plates measured.

The variations of *101659*, *110060*, *120658*, and *124058*, which are difficult to observe on account of their small range, or from the close proximity of other stars, have been confirmed by Mrs. Fleming. Variations as great as 0.7 magnitude are conspicuous on these plates.

An ephemeris for *121249* is given in Table II. The first column gives the value of every fifth time of minimum, for about six months, beginning with Epoch 1450. The second and third columns give the Julian Day and decimal following Greenwich Mean Noon, and the corresponding date and Greenwich Mean Time of minima.

TABLE II.
EPHEMERIS FOR *121249*.

Epoch.	J. D. ^o	Date.					Epoch.	J. D.	Date.				
		y.	m.	d.	h.	m.			y.	m.	d.	h.	m.
1450	7571.074	1906	December	26	1	47	1470	7675.462	1907	April	9	11	7
1455	7597.171	1907	January	21	4	7	1475	7701.559	"	May	5	13	27
1460	7623.268	"	February	16	6	27	1480	7727.656	"	"	31	15	47
1465	7649.365	"	March	14	8	47	1485	7753.753	"	June	26	18	7

EDWARD C. PICKERING.

NOVEMBER 24, 1906.

HARVARD COLLEGE OBSERVATORY.

CIRCULAR 123.

PHOTOGRAPHS OF FAINT STARS.

THE number of facts now being accumulated by means of photographs of the stars is enormous. Unfortunately, only a small portion of these facts is now available, and therefore of any use to science. This applies particularly to the faint stars. Many photographs are taken by professional and amateur astronomers, which are followed carefully during long exposures with telescopes having large apertures. In some cases, several hundred thousand stars appear upon a single plate. Unfortunately, no record has been published of many of these photographs, and therefore no use can be made of them. It is the object of the plan described below to remedy this difficulty.

The Harvard collection of photographs in part supplies this need, for stars of the thirteenth magnitude and brighter. On the average, this collection contains images of all the stars of the fifth magnitude and brighter on over a thousand nights. The number of these stars is about two thousand, the photographs are distributed throughout the last twenty years, and cover all parts of the sky. For stars of the twelfth magnitude, which can be taken with a lens of 1-inch aperture and an exposure of one hour, the number is reduced to five hundred. This includes the stars in the Harvard Map of the sky, about two million in number. There are about five million stars of the thirteenth magnitude and brighter. They appear on plates taken with 8-inch doublets, and having exposures of ten minutes. About two hundred images of each of these are contained in the Harvard collection. For fainter stars, the number of images falls off very rapidly. Stars of the fourteenth magnitude would appear on plates, having exposures of ten minutes, taken with the 24-inch Bruce telescope, and on plates, having exposures of an hour, taken with the 8-inch telescopes. The average number of times the whole sky is thus covered does not exceed three or four. A large part of the southern sky is covered by plates having an exposure of an hour or more, taken with the 24-inch Bruce telescope.

160 regions, covering a tenth of the sky, have exposures of four hours. While, therefore, material exists for studying the variability of stars of the thirteenth magnitude or brighter, but few images can be found of stars much fainter than this limit, except in special regions like the Nebula of Orion. This limit could probably be extended nearly two magnitudes, if the following plan could be carried out. For the present it seems best to confine this work to photographs having an exposure of half an hour or more, and taken with doublets whose aperture is 6 inches or more. Photographs taken with large reflectors or single lenses may take fainter stars, but in general they relate to special regions and except in the charts of the Astrographic Congress do not cover large parts of the sky. The latter great work will of course, eventually, furnish one or two images of all stars of the fourteenth magnitude, and brighter.

Information is frequently desired regarding very faint stars. For instance, evidence of the previous existence of a new star; of a star now missing; the position of an asteroid; the magnitude at minimum of a faint variable; early position of a faint star suspected of proper motion. Three questions suggest themselves. Where are the principal collections of photographs showing faint stars, and what is their character and extent? Does a photograph exist which is likely to contain the required information? Is this photograph accessible, so that the information desired can be secured from it? Satisfactory answers to these questions can generally be obtained for stars brighter than the thirteenth magnitude but not for fainter stars. Astronomers having collections of photographs showing such faint stars are urged to publish the material required to answer these questions, or to send the information needed to this Observatory. The principal facts desired are given below:—

1. A description of the instrument, stating its location; form of lens; maker; aperture; focal length, or scale of photograph, that is, number of seconds of arc to the millimetre; size of plate, or region covered; diameter of circle over which stars as faint as the fourteenth magnitude are shown; kind of plate used; name of observer.

2. A list of photographs, which should include the number designating each plate; the time of the centre of the exposure (found by adding half the duration of the exposure to the time of beginning), expressed either in Julian Days and thousandths following Greenwich Mean Noon, or in calendar days, hours, and minutes; the right ascension and declination for 1900 of the centre of the plate; the time of exposure in minutes; the quality on a scale of 5, 5 denoting that the images are circular and that no serious defect appears upon the plate,

4 that the images are nearly circular so that their positions can be accurately measured, 3 that faint stars are shown so that the relative brightness can be accurately estimated, even if the images are not circular.

3. A statement whether the owner is willing to examine and if necessary measure his photographs to furnish any desired information; to lend them under suitable restrictions, so that copies may be made; to furnish contact prints at cost.

It is the policy of the Harvard Observatory to make the material it has collected as widely useful as possible. Accordingly, preparations are being made to publish the facts asked for in Nos. 1 and 2. For many years the Observatory has offered to furnish copies of its photographs at cost to whoever might desire them. If this policy is adopted at other observatories, a purchase of large numbers of photographs of faint stars is contemplated here. The Observatory will take charge, temporarily or permanently, of good photographs for which the owners have no further use, and will render them accessible to astronomers by the methods described above.

EDWARD C. PICKERING.

JANUARY 19, 1907.

HARVARD COLLEGE OBSERVATORY.

CIRCULAR 124.

STARS HAVING PECULIAR SPECTRA. 18 NEW VARIABLE STARS.

EXAMINATIONS of late photographs of the Henry Draper Memorial, by Mrs. Fleming, has led to the discovery of a number of variable stars and other objects having peculiar spectra. A list of these is given in Table I, together with two additional variables found by examination of chart plates, one by Miss Annie J. Cannon and one by Miss L. D. Wells. The constellation and the number in the Durchmusterung are given in the first two columns. The approximate right ascension and declination for 1900 and the catalogue magnitude, are given in the third, fourth, and fifth columns. The catalogue designations and magnitudes are taken from the Bonn Durchmusterung, when the star is north of declination -23° , from the Cordoba Durchmusterung, when between declinations -23° and -52° , and from the Cape Photographic Durchmusterung, when south of declination -52° . The class of spectrum and a brief description of the object are given in the sixth and seventh columns. Each of the new variables has been confirmed independently by another observer. 001828 and 091151 were confirmed by Mrs. Fleming, the remainder were confirmed by Miss L. D. Wells. Additional information regarding these objects is given in the remarks following the table. In the case of new variable stars the right ascension is followed by the designation described in the Annals, 48, 93, which gives the approximate position, and also by the designation described in the Annals, 53, No. 7, which indicates the number in the series of variables found at Harvard. This last number is also given in the table, for convenience of future reference. The approximate galactic longitudes and latitudes of the gaseous nebulae are given in the Remarks following Table I.

TABLE I.
PECULIAR SPECTRA.

Constellation.	DM. No.	R. A. 1900.	Dec. 1900.	Magn.	Spectrum.	Description.
		<i>h. m.</i>	<i>° '</i>			
Andromeda	+28° 54	0 18.4	+28 51	9.0	..	Variable. H 1305.
Andromeda	..	1 10.4	+41 12	..	Md	Variable. H 1306.
Perseus	+47° 939	4 1.4	+47 28	4.5	B Pec.	H β bright.
Camelopardus	+57° 806	4 22.4	+57 11	8.5	Md?	Variable. H 1307.
Cancer	..	9 2.2	+21 58	..	N	Type IV.
Ursa Major	+52° 1378	9 11.5	+51 50	9.2	..	Variable. H 1308.
Carina	-64° 1475	10 42.5	-65 5	9.5	N	Variable. H 1309.
Carina	..	10 56.5	-64 42	..	Pec.	Bright lines. Gaseous Nebula.
Crux	-62° 2898	12 36.9	-62 30	6.6	B Pec.	H β bright.
Draco	+66° 780	12 52.5	+66 32	7.3	N	Variable. H 1310.
Musca	..	13 2.2	-67 6	..	Pec.	Bright lines. Gaseous Nebula.
Centaurus	..	13 13.2	-60 15	..	Md?	Variable. H 1311.
Centaurus	-62° 3270	13 20.7	-62 8	8.1	B Pec.	H β bright.
Virgo.	..	14 22.4	- 0 26	..	..	Variable. H 1312.
Centaurus	-31° 11294	14 28.1	-31 15	9.1	Md	Variable. H 1313.
Bootes	+32 2489	14 29.2	+32 11	9.3	..	Variable. H 1314.
Lupus	..	14 52.3	-54 33	..	Md	Variable. H 1315.
Corona Borealis	+38° 2698	15 43.0	+38 35	9.5	Mc 5 d	Variable. H 1316.
Corona Borealis	..	15 52.2	+29 32	..	Md	Variable. H 1317.
Norma	-60° 6348	15 55.2	-60 13	7.9	Pec.	H γ , H β bright.
Hercules	+12° 2966	16 7.0	+12 20	9.0	Pec.	Bright lines. Gaseous Nebula.
Scorpius	-37° 11206	16 57.2	-37 42	7.1	Pec.	Similar to ζ Puppis.
Apus	-81° 782	16 58.4	-81 26	9.6	Pec.	Dark bands.
Scorpius	-33° 11875	17 8.7	-33 26	..	B Pec.	H β bright.
Apus	-81° 787	17 11.0	-81 31	..	Pec.	Dark bands.
Ara	-47° 11484	17 15.8	-47 23	..	B Pec.	H β bright.
Ara	-46° 11530	17 20.5	-46 57	..	B Pec.	H β bright.
Sagittarius	R	19 10.5	-39 47	R	..	Variable. H 1318.
Aquila	-10° 5057	19 17.7	-10 54	7.0	Pec.	Dark bands.
Aquila	..	19 52.0	- 9 37	..	..	Variable. H 1319.
Delphinus	+15° 4172	20 24.6	+15 56	..	Mc	Variable. H 1320.
Delphinus	..	20 24.6	+15 56	..	..	Variable. H 1321.
Lacerta	R	22 45.4	+40 30	..	Mc 5 d	Variable. H 1322.

REMARKS.

h. m.

0 18.4. 001828=H 1305. Discovered by Miss A. J. Cannon, from an examination of chart plates taken with the 1-inch Cooke lens. Observations of four hundred and sixty-one plates, taken between November 14, 1889, and November 16, 1906, show a variation of about 1.2 magnitudes. Approximate limits of magnitude 8.7 to 9.9. Period 0^d.49932.

h. m.

1 10.4. 011041=H 1306. An examination of this star on twelve chart plates, taken between February 19, 1891 and July 21, 1904, shows a variation of about 5.0 magnitudes. Estimates from these plates give the approximate limits 8.0 to <13.

4 1.4. Plate C 16052, taken on October 5, 1905, with the 11-inch Draper Telescope shows the line H β bright,

h. m.

- and the lines $H\gamma$ and $H\delta$ appear to be double, probably due to fine bright lines superposed on them.
- 4 22.4. 042257=H 1307. An examination of this star on twenty-three chart plates, taken between January 3, 1890, and October 9, 1905, shows a variation of about 1.7 magnitudes. Estimates from these plates give the approximate limits, 7.8 to 9.5. Suspected of variability by Espin. *Astron. Nach.* **134**, 123, and **145**, 327.
- 9 2.2. This is a difficult object on Plate I 32758, taken on February 27, 1905 with the 8-inch Draper Telescope. A better photograph may show more detail, and place it in the class of spectra similar to C. DM. -47° 6614, described in Circular 76. On two plates, I 24997, taken April 1, 1900 and I 33005, taken April 22, 1905, the spectrum is too faint to be classified.
- 9 11.5. 091151=H 1308. Discovered by Miss L. D. Wells. An examination of this star on ten chart plates, taken between March 7, 1892 and March 6, 1903, shows a variation of about 0.8 magnitude. Estimates from these plates give the approximate limits 11.1 to 11.9.
- 10 42.5. 104265=H 1309. An examination of this star on thirteen chart plates, taken between May 6, 1890 and December 6, 1904, shows a variation of about 1.2 magnitudes. Estimates from these plates give the approximate limits, 8.4 to 9.6.
- 10 56.5. Galactic longitude, 259°. Galactic latitude, -5°. This object precedes 1° 3, and is 63" north of C. P. D. -64° 1588, magn. 9.5.
- 12 36.9. On Plate X 11195, taken on May 31, 1906, with the 13-inch Boyden Telescope, $H\beta$ appears as a fine dark line superposed on a broad bright line. The lines $H\gamma$ and $H\delta$ are bright on the edge of greater wave length.
- 12 52.5. 125266=H 1310. An examination of this star on eight chart plates, taken between April 11, 1892 and May 15, 1902, shows a variation of about 2.0 magnitudes. Estimates from these plates give the approximate limits, 8.5 to 10.5.
- 13 2.2. Galactic longitude, 273°. Galactic latitude, -5°.
- 13 13.2. 131360=H 1311. An examination of this star on nine chart plates, taken between June 22, 1893 and June 21, 1904, shows a variation of about 3.0 magnitudes. Estimates from these plates give the approximate limits, 10.5 to 13.5. The variability of this star was discovered independently by Miss H. S. Leavitt, by the method of superposing negatives on a positive plate.
- 13 20.7. Plate B 35759, taken on April 5, 1905, with the 8-inch Bache Telescope, shows the line $H\beta$ bright in the spectrum of this star.
- 14 22.4. 142200=H 1312. An examination of this star on sixteen plates, taken between March 11, 1897 and May 24, 1906, shows a variation of about 1.4 magnitudes. Observations give the approximate limits, 9.1 to <10.5. This variable, which has a period of 0d.41224, was discovered from a plate taken at Are-

h. m.

- quipa with the 1-inch Cooke lens, on May 19, 1906, and having fifteen exposures of 30 minutes each.
- 14 28.1. 142831=H 1313. An examination of this star on thirteen plates, taken between July 16, 1891 and May 13, 1904, shows a variation of about 5.0 magnitudes. Estimates from these plates give the approximate limits, 9.0 to 14.0.
- 14 29.2. 142932=H 1314. Observations of this star on two hundred and seventy-four plates, taken between July 8, 1890 and July 9, 1906, show a variation of about 1.1 magnitudes, the approximate limits being 8.9 to 10.0. This variable, which has a period of 0d.49931, was discovered from a plate taken at Arequipa with the 1-inch Cooke lens, on May 24, 1906, and having seventeen exposures of 30 minutes each.
- 14 52.3. 145254=H 1315. An examination of this star on eleven plates, taken between May 25, 1891 and August 19, 1905, shows a variation of about 5.0 magnitudes. Estimates from these plates give the approximate limits, 8.5 to 13.5.
- 15 43.0. 154338=H 1316. An examination of this star on sixteen plates, taken between July 2, 1893 and February 17, 1905, shows a variation of about 2.0 magnitudes. Estimates from these plates give the approximate limits, 8.5 to 10.5.
- 15 52.2. 155229=H 1317. An examination of this star on ten chart plates, taken between May 25, 1891 and May 8, 1905, shows a variation of about 3.0 magnitudes. Estimates from these plates give the approximate limits 8.0 to <11.0.
- 15 55.2. Plates X 1205 and X 11221, taken at Arequipa on June 9, 1906 and June 13, 1906, respectively, with the 13-inch Boyden Telescope, show the lines $H\beta$ and $H\gamma$ bright in the spectrum of this star. There is also a trace of a bright $H\delta$ line.
- 16 7.0. Galactic longitude, 353°. Galactic latitude +40°. An examination of this object on twenty-seven chart plates, taken between July 18, 1890 and June 22, 1905, shows a distinct change of about 0.4 magnitude which may be due to the photographs. The change is most noticeable on the sixteen plates taken with the 1-inch Cooke lens. This small change in magnitude has been confirmed independently by Miss Wells.
- 16 57.2. The spectrum of this star on Plate X 11191, taken at Arequipa on May 29, 1906, with the 13-inch Boyden Telescope, shows the bright lines at wave lengths 4652 and 4698, and the additional dark lines, 4027, 4202, and 4544, characteristic of the spectrum of ζ Puppis. Announced as a star of the fifth type, *Astron. Nach.* **123**, 95.
- 16 58.1. This spectrum is similar to that of C. DM. -47° 6614, described in Circular 76.
- 17 8.7. Plates X 11001 and X 11007, taken at Arequipa on July 1, 1905 and July 3, 1905, with the 13-inch Boyden Telescope, show the line $H\beta$ bright in the spectrum of this star.

- | | |
|---|---|
| <p><i>h. m.</i></p> <p>17 11.0. This spectrum is similar to that of C. DM. -47° 6614 described in Circular 76.</p> <p>17 15.8. Plate X 11235, taken at Arequipa on June 25, 1906, with the 13-inch Boyden Telescope, shows the line $H\beta$ bright in the spectrum of this star. $H\gamma$ appears as a fine narrow bright line superposed on a broad dark line.</p> <p>17 20.5. Plate X 11235, taken at Arequipa on June 25, 1906, with the 13-inch Boyden Telescope, shows the line $H\beta$ bright in the spectrum of this star.</p> <p>19 10.5. 191039=H 1318. Observations of this star on one hundred and sixty-six plates, taken between July 5, 1889 and July 1, 1904, show a variation of about 2.6 magnitudes. Estimates from these plates give the approximate limits, 9.8 to 12.4. Photographic observations of this star were exceedingly difficult, as it is involved in a nebula whose centre is in the same right ascension, and is 14" south of it. It is uncertain whether C.DM. -39° 13207, magn. 9.5, represents an observation of the variable, the nebula, or the combined light of both.</p> <p>19 17.7. This spectrum is similar to that of C.DM. -47° 6614, described in Circular 76.</p> <p>19 52.0. 195209=H 1319. This variable was found from chart plates, while searching for Iris. An ex-</p> | <p><i>h. m.</i></p> <p>amination of this star on nine chart plates, taken between November 16, 1894 and September 18, 1906, shows a variation of about 1.9 magnitudes. Estimates from these plates give the approximate limits, 9.6 to <11.5.</p> <p>20 24.6a. 202415a=H 1320. Observations of this star on two hundred and twenty-one plates, taken between July 31, 1890, and November 9, 1905, show a variation of about 0.9 magnitudes, the approximate limits being 8.9 to 9.8.</p> <p>20 24.6b. 202415b=H 1321. A faint star about 20" distant, following and south of 20h 24m.6a. Observations of this star on seventy-four plates, taken between July 21, 1890 and November 9, 1905, show a variation of about 1.0 magnitude, the approximate limits being 11.8 to <12.8.</p> <p>22 45.4. 224540=H 1322. The preceding and southern of a pair of stars, about 40" apart, either of which might be identified as +40° 4920, magn. 9.1. An examination of this star on thirteen chart plates, taken between November 20, 1891 and November 2, 1902, shows a variation of about 1.5 magnitudes. Estimates from these plates give the approximate limits, 8.2 to 9.7.</p> |
|---|---|

Plate A 7588, taken at Arequipa with the 24-inch Bruce Telescope on January 30, 1906, and having an exposure of 64^m, shows the spectrum of a moving object, whose approximate position for 1875 is in R. A. = 9^h 38^m.1, Dec. = -79° 58'. The class of spectrum is similar to that of the Sun, and the magnitude is about 9.5. If this object is an asteroid it is of great interest owing to its southern declination.

Since Circular 111 was published, the spectra of the known variable stars, 132262 RR Ursae Majoris, 170627 RT Herculis, and 215934 RT Pegasi, have been photographed, and give the classes of spectra of these objects as Md?, Md 4, and Md?, respectively.

EDWARD C. PICKERING.

JANUARY 26, 1907.

HARVARD COLLEGE OBSERVATORY.

CIRCULAR 125.

STANDARD STELLAR MAGNITUDES.

A SIMPLE method of determining the photographic magnitudes of the stars, on a uniform scale, even if they are widely apart, has been in use here for several years. A brief description of it is given in Circular 108. Its advantages are that no special apparatus is required, and that the results obtained by it in practice are very satisfactory.

A determination by this method of a large number of standards of photographic magnitude, uniformly distributed throughout the sky, is now in progress. A full description of the method and the resulting magnitudes is in preparation for publication in the *Annals*. The object of the present publication is to place in the hands of astronomers a means of determining promptly photographic magnitudes on the scale adopted here.

A standard sequence of comparison stars near the North Pole was selected, and their photometric magnitudes determined from a large number of measures with the 4-inch and 12-inch Meridian Photometers. The positions and magnitudes of these stars are given in Table I. The letter designating them is given in the first column, and the *Durchmusterung* number in the second. All of these stars, except d, f, and g, are contained in the list of stars proposed as standards of magnitude in 1879, *Astron. Nach.* 95, 29.

Stars a and b are easily recognized as the two brightest stars near the Pole Star. All of the others are shown on Plate I, accompanying *Annals*, 48, No. I. Their coördinates in millimetres, measured from the left-hand lower corner of that plate, are given in the third column. The precise rectangular coördinates, with the position of the Pole for 1900.0 as an origin, are given in the fourth and fifth columns. Adding 1800" to these coördinates and dividing by 20 gives nearly the same quantities as those contained in the third column, except that the order of the coördinates is reversed. The sixth column gives the photometric magnitude. Several of these magnitudes depend on many hundred observations,

since for the last eight years they have been used as standards, and measured at the beginning and end of each evening's observation with the 12-inch Meridian Photometer. The seventh column gives the adopted photographic magnitudes of these stars. They were derived from measures made by Miss Leland, of 70 photographic plates.

TABLE I.
POLAR SEQUENCE.

Letter.	DM.	48, I.	x	y	Photometric.	Photographic.
a	+88° 4	..	+5285	+1308	6.43	6.40
b	+88° 9	..	+3894	+2582	7.97	7.98
c	+89° 3	131, 126	+ 728	+ 860	8.94	8.96
d	+89° 29	42, 48	— 860	— 973	10.25	10.21
e	+89° 35	55, 67	— 429	— 708	9.84	10.64
f	+89° 31	30, 69	— 388	—1221	10.39	11.19
g	..	67, 86	— 54	— 467	12.22	..
h	..	76, 95	+ 134	— 267	12.65	12.70
k	..	85, 89	+ 12	— 86	13.34	13.27
l	..	90, 86	— 87	+ 2	13.94	..

To determine the photographic magnitudes of any stars on this scale, a photograph is first taken of the North Pole, and the standard stars are marked on it. This plate need not be a good one, so long as it shows star h, and perhaps k, and it can be used indefinitely for stars in all parts of the sky. A second plate is then taken of the stars to be measured. Again, it is only necessary that it should show these stars, good images not being essential. The stars whose magnitudes are desired are marked on it, or better, a sequence of stars is selected and marked, each star being slightly brighter than the one next it, and including stars brighter and fainter than any that are to be measured. The third plate is the important one. It must be taken when the sky is perfectly clear and free from clouds or irregularly distributed haze, and at a time when the given region is at nearly the same altitude as the Pole. Under these conditions a photograph of the region is taken in the usual way, and a second exposure of exactly the same length is made upon the Pole. It is essential that the images in the two exposures should be so nearly alike that they cannot be distinguished easily. The stars of the polar sequence are now transferred to this photograph by superposing it on the polar plate. The other stars are similarly marked by means

of the second plate. The relative brightness of the two sets of images is then measured by any convenient method. That proposed by Bond in 1858, and generally employed elsewhere than at Harvard, consists in measuring the diameters of the images. Other methods are preferred here and are described in the *Annals*, 26, 249. Comparisons are sometimes made with a series of images taken with different exposures, sometimes each star is compared directly with brighter and fainter stars of the standard sequence. The relative brightness of the stars being thus determined upon an arbitrary scale, the absolute magnitude can be determined at once, graphically. A rapid and convenient method is to mark the photographic magnitude opposite each star of the polar sequence, and then estimate directly the magnitudes of the other stars. Thus, a star a little fainter than d, 10.2, and much brighter than e, 10.6, would be called 10.3.

It will be noticed that, in Table I, the photometric and photographic magnitudes are nearly the same for all the stars, except e and f. The spectra of these last stars are of the second type, and their color is reddish. According to the measurements made here, they are about 0.8 magn. brighter photometrically than photographically. This difference would vary with the absorption of the lenses and the character of the plates, and would probably be smaller with a reflector.

EDWARD C. PICKERING.

FEBRUARY 25, 1907.

HARVARD COLLEGE OBSERVATORY.

CIRCULAR 126.

TWO VARIABLES DISCOVERED BY M. BAILLAUD.

IN the Comptes Rendus, 144, 250, M. Jules Baillaud announces the discovery of two new variable stars whose changes in light are so rapid, that they are well shown on the plates of the Paris Observatory, having three successive exposures at intervals of half an hour. These stars are so faint that, as stated in Circular 124, it is not probable that many photographic images of them exist. It will now be easy to determine the light curves and approximate periods of these stars by taking series of photographs at short intervals. The precise periods can then be determined with great accuracy from early photographs, especially if they were taken at a time when the light was changing rapidly. To make these observations of value, we must know the exact time of the centre of the exposure, and the brightness of the variable compared with that of adjacent stars, so that all the observations can be reduced to a standard scale. An examination by Mrs. Fleming of the plates in the Harvard collection led to the results given below.

The position of the first star is in R. A. $16^h 54^m.2$, Dec. $+21^\circ 42'$ (1900). The position of the second star, according to M. Baillaud, is in R. A. $19^h 0^m 8^s.44$, Dec. $+24^\circ 40' 15''.8$ (1900). It would therefore precede $+24^\circ 36' 24''$, $36^s.6$, south $5' 41''$. No star appears in this position on the Paris chart, Zone $+24^\circ$, No. 144. A star which precedes $+24^\circ 36' 24''$, 19^s , south $8'.6$, is variable, and has been assumed to be the object. It has a fainter star which precedes it $0^s.9$, south $14''$. These two stars are not separated on some of the plates taken with the 8-inch telescope, and the combined light is estimated.

In order that the magnitudes here found for the variables may be compared with those of later photographs, six stars have been selected near the first variable and magnitudes assigned to them arbitrarily. An attempt was made to conform to the scale of M. Baillaud as nearly as possible. The magnitudes and coördinates of these stars, referred to the variable as an origin, are given

in the first three columns of Table I. The magnitudes and coördinates of four comparison stars of the second variable are given in the next three columns of the same table.

TABLE I.
COMPARISON STARS.

Magnitudes.	x	y	Magnitudes.	x	y
	"	"		"	"
12.7	- 54	-414	13.0	-165	-310
12.9	-496	+ 78	13.4	-354	- 30
13.4	-268	+ 45	14.0	- 48	-132
13.8	+210	-285	14.2	- 24	- 42
14.2	+102	+ 45			
14.5	- 82	- 38			

The first portion of Table II contains, for the first variable, the designation of the plate, the date, the Julian Day and decimal following Greenwich Mean Noon of the middle of the exposure, the duration of the exposure, and the esti-

TABLE II.
OBSERVATIONS OF VARIABLES.

Plate.	Date.	J. D.	Exp.	Est.	Plate.	Date.	J. D.	Exp.	Est.
			<i>m.</i>					<i>m.</i>	
I 8981	1893 7 29	2674.567	16	14.2	I 8957	1893 7 27	2672.649	10	14.3
A 397	1894 3 16	2904.875	10	13.7	A 779	1894 8 11	3052.564	10	13.7
I 11100	" 5 14	2963.766	12	12.7	I 11647	" 10 15	3117.505	10	13.8
I 18874	1897 9 17	4185.549	10	13.0	A 1937	1896 7 20	3761.612	11	14.1
I 18953	" " 21	4189.543	13	14.2	I 16090	" 10 3	3836.550	10	13.8
I 20661	1898 4 7	4387.873	12	13.0	I 16380	" " 28	3861.502	14	13.0
A 3146	" 6 29	4470.628	11	14.8	A 2681	1897 8 31	4168.531	75	13.8
I 23345	1899 8 16	4883.584	10	13.2	A 3211	1898 8 5	4507.609	10	13.7
A 5337	1901 6 8	5544.749	60	14.8	A 3212	" " 5	" .620	10	13.7
I 27144	" " 27	5563.607	17	13.0	A 3214	" " 5	" .652	10	14.2
A 5482	" 7 25	5591.607	10	14.7	I 21261	" 9 28	4561.558	10	14.0
I 30529	1903 5 20	6255.759	31	13.2	A 5558	1901 8 21	5618.575	60	14.0
I 34336	1906 11 8	7523.460	26	12.9	I 27433	" 9 6	5634.566	35	13.7
					I 30763	1903 8 24	6351.657	16	13.9
					I 33738	1905 12 8	7188.441	26	14.2
					I 34139	1906 7 14	7406.721	20	14.0
					A 7881	" " 21	7413.661	60	13.7

mated magnitude. Photographs taken with the 24-inch Bruce Telescope are indicated by the letter A, those taken with the 8-inch Draper Telescope, by the letter I. Plate I 18953 is an isochromatic plate. When the variable is not seen on the plate, the magnitude of the faintest star shown is given in Italics. Thus, at the time the second plate was taken, the variable must have been fainter than magnitude 13.7, since stars of that magnitude appear on the plate. The observations of the second variable are given in the same form in the second part of Table II.

It will be noticed that several plates in these tables show stars estimated as of the fourteenth magnitude or fainter, although taken with a telescope having an aperture of only 8 inches, and an exposure of ten minutes. It is stated in Circular 123, that such plates seldom show stars much fainter than the thirteenth magnitude on the Harvard scale. It is therefore probable that the scale of M. Baillaud differs systematically from that in use here.

EDWARD C. PICKERING.

FEBRUARY 25, 1907

HARVARD COLLEGE OBSERVATORY.

CIRCULAR 127.

NEW VARIABLE STARS IN HARVARD MAP, Nos. 3 AND 6.

IN Circular 116, Professor Bailey proposed a Durchmusterung of Variable Stars, or an exhaustive study of these stars in all portions of the sky. While this plan seems at present beyond our reach, it may be approached by a search for variables in all parts of the sky, according to a uniform system. The Harvard Map of the Sky, described in Circular 71, divides the entire sky into 55 portions each approximately 30° square. The study of one of these, No. 50, by Miss Leavitt, described in Circular 122, shows that large numbers of moderately bright variable stars are probably still unknown, and that many of them may readily be discovered by the method of superposing a negative upon a contact print of a second negative covering the same region. The sky has accordingly been divided into three parts, that covered by Nos. 1, 4, 7, 10, etc., being assigned to Miss Cannon, Nos. 2, 5, 8, 11, etc., to Miss Leland, and Nos. 3, 6, 9, 12, etc., to Miss Leavitt. For each region, five plates are selected and a contact print made from one of them. The other four are then superposed on this print in turn, and the stars showing evidence of variability marked. Some of these prove to be known variables, some to be new variables, some are still suspected of variability, and the others are not confirmed and seem to be due to photographic defects or other causes of error. From the number of new variables found by superposing plates of the same region an estimate may be made of the number still undiscovered. Thus, if nine-tenths of them were new, we might expect that many more would be found from other plates, while if only one-tenth were new we should expect that nine-tenths of the whole number were already known. Doubtless, many more could be found by superposing more plates, but in that case a second contact print also should be used. It seems best, first, to cover the whole sky by the method here described, and thus provide for determining the probable distribution. Later, if desired, the work can be extended, but probably this could be done better by means of photographs taken with a large instrument. An examination of Regions 3 and 6 has already

been made by Miss Leavitt, with the results given below. It seems best to make an announcement of the new variables at once, reserving for a later publication in the *Annals*, a detailed study of their variations.

The photographs used in the examination are described in Table I. The number of the region in the Map of the Sky and the position of the centre are given in the first two columns. The third column contains a number for the negative whose designation follows in the fourth column. The negatives, five for each region, are numbered in the order in which they were examined, No. 1 being the plate from which the glass positive was made, and Nos. 2, 3, 4, and 5 having been successively superposed on it. An additional line, for each region, gives the results obtained from all the five plates. The date on which the photograph was taken and the Julian Day and decimal following Greenwich Mean Noon, corresponding to the centre of the exposure, are given in the fifth and sixth columns. The number of new variables discovered, the total number found on the plate, including known variables, and the proportion of new variables, are given in the seventh, eighth, and ninth columns. In the last line of each portion of the table, the total number of variables found, and given in the eighth column, does not equal the numerical sum of the numbers above it, as some variables were independently discovered on more than one plate. The whole number of variables known at the conclusion of the examination of the plate is given in the tenth column. Novae, variables in clusters, variables

TABLE I.
PLATES COMPARED.

No.	Region.	No.	Plate.	Date.	J. D.	New Var.	Total found.	Proport'n new.	All.	Probable No.	Proport'n found.
3	$h. \quad ^\circ$ 3 +60	1	AC 5369	y. m. d. 1904 10 15	6769.770	..	..	..	18	..	..
		2	AC 8088	1906 12 6	7551.638	2	4	.50	20	36	.10
		3	AC 6809	1905 10 8	7127.742	1	2	.50	21	40	.05
		4	AC 7940	1906 10 25	7509.767	4	8	.50	25	42	.19
		5	AC 4619	1904 2 8	6519.534	1	6	.17	26	30	.14
		All	...	...	...	8	14	..	26	42	.33
6	12 +60	1	AC 7427	1906 3 31	7301.663	..	..	..	15	..	..
		2	AC 3351	1903 2 23	6169.826	2	4	.50	17	30	.14
		3	AC 3466	1903 3 31	6205.779	1	6	.17	18	20	.22
		4	AC 6178	1905 3 15	6920.800	3	7	.43	21	32	.25
		5	AC 2534	1902 5 9	5879.626	0	9	.00	21	21	.32
		All	...	...	...	6	13	..	21	28	.43

fainter at maximum than the tenth magnitude, and suspected variables, are omitted, as it is improbable, though not impossible, that an object belonging to one of these classes should be discovered in this research. The number of known variables contained in the Second Catalogue of Variable Stars, Annals 55, Part I, excluding the classes mentioned, is 18 in region 3 and 15 in region 6. In order to estimate the whole number of variables probably existing in the region, the proportion was used that the number of known variables discovered is to the total number discovered, as the total number already known is to the whole number in the region. This number is given in the eleventh column of Table I. The summary of the results obtained from the five plates, indicates that in region 3 there are probably 42 variables, of which 16, or about two-fifths, remain to be discovered. In region 6, the probable number is 28, of which 7, or one-fourth remain to be discovered. If only the more striking variables are taken into account, these results are greatly modified, for it will be found in Table III that none of the new variables have a range of more than a magnitude, or are brighter than the eighth magnitude. Apparently nearly all the variables, in these regions, which are bright and show conspicuous changes, have been discovered. The last

TABLE II.
KNOWN VARIABLES.

Des.	Name.	Max.	Min.	Class.	Year of Dis-covery.	Found on Plates.	Des.	Name.	Max.	Min.	Class.	Year of Dis-covery.	Found on Plates.
011272	S Cassiop.	7.6	14.5	II	1861	...	044068	— Camelop.	...	...	III	1902	...
013057	RW Cassiop.	8.9	11.0	IV	1905	2 ...	100860	U Urs. Maj.	7.0	8.3	III	1898	...
014958	X Cassiop.	9.0	12.3	II	1895	...	103769	R Urs. Maj.	7.0	13.5	II	1853	2 3 4 5
015354	U Persei	7.5	11.0	II	1890	3 4 5	103867	— Urs. Maj.	...	...	...	1906	...
020448	RV Androm.	8.5	10.5	II	1904	...	113972	Z Draconis	9.9	13.6	V	1903	...
021556	RS Persei	8	10	...	1904	...	115158	Z Urs. Maj.	...	...	II	1904	3 5
021558	S Persei	7.8	11.2	II	1874	...	121561	— Urs. Maj.	...	...	...	1906	...
022150	RR Persei	9	<13	II	1904	...	123160	T Urs. Maj.	6.4	13.1	II	1860	...
023947	— Persei	...	...	V	1906	...	123366	— Draconis	9.7	<12.5	...	1906	3 5
023969	RZ Cassiop.	6.4	7.8	V	1906	...	123459	RS Urs. Maj.	9.2	14.5	II	1905	...
024368	— Cassiop.	...	...	IV	1906	...	123556	Y Urs. Maj.	8	9	III	1904	...
024356	W Persei	7.5	11.5	II	1893	...	123961	S Urs. Maj.	7.3	12.5	II	1853	3 4 5
025867	RX Cassiop.	8.6	9.1	V	1904	...	125266	— Draconis	8.5	10.5	...	1906	...
031646	RT Persei	9.5	11.5	V	1904	...	132262	RR Urs. Maj.	9.4	<12	II	1905	...
042257	— Camelop.	7.8	9.5	...	1906	...	133273	T Urs. Min.	8.5	<13	II	1903	...
043065	T Camelop.	7.0	13.5	II	1891	...	141567	U Urs. Min.	8.5	12	II	1904	2 4 5
043274	X Camelop.	8.0	13	II	1903	2 ...							

column of Table I gives, for each plate, the proportion of the computed total actually found.

A list of known variables in these two regions has been made from the Second Catalogue of Variable Stars, Annals 55, Part I, and is given in Table II. Stars in the classes mentioned in the foregoing paragraph are omitted. The first six columns contain the designation, name, maximum and minimum magnitudes, class of variation, and year of discovery. The last column indicates on which plates, if any, the variable was rediscovered. The numbers correspond to those in the third column of Table I.

The new variables are given in Table III, in which the successive columns give the designation, Harvard Number, constellation, number in the Bonn Durchmusterung, right ascension and declination for 1900, brightest and faintest magnitudes as yet observed, range, and numbers of the plates on which the variable was independently discovered.

TABLE III.
NEW VARIABLES.

Design.	Harvard No.	Constellation.	DM. No.	R. A. 1900.	Dec. 1900.	Br.	Ft.	Range.	Found on Plates.
				<i>h. m. s.</i>	<i>° ' "</i>				
020057	2891	Perseus	+57° 489	2 0 48	+57 58.2	9.3	10.0	0.7	2 . . .
021556b	2892	Perseus	+55° 597	2 15 5	+56 8.8	9.2	10.1	0.9	. . 4 .
021959	2893	Cassiopeia	+58° 470	2 19 51	+59 0.6	10.6	11.2	0.6	. . 4 .
023765	2894	Cassiopeia	+65° 289	2 37 38	+65 18.6	8.2	9.0	0.8	. . 4 .
024462	2895	Cassiopeia	+62° 480	2 44 24	+62 22.4	8.8	9.4	0.6	2 . 4 .
034658	2896	Camelopard.	+58° 663	3 46 9	+58 21.6	9.0	10.0	1.0	. . . 5
035658	2897	Camelopard.	+58° 694	3 56 43	+58 22.9	8.6	9.2	0.6	. 3 4 5
042164	2898	Camelopard.	+64° 451	4 21 28	+64 13.5	9.5	10.5	1.0	. . 4 5
112245	2899	Ursa Major	+45° 1924	11 22 22	+45 44.2	8.2	9.0	0.8	2 . . .
113267	2900	Draco	+68° 652	11 32 14	+67 53.2	9.0	9.7	0.7	. 3 4 5
113552	2901	Ursa Major	+52° 1579	11 35 24	+52 33.9	9.5	10.5	1.0	. . 4 .
121270	2902	Draco	. . .	12 12 48	+70 4.0	8.8	9.6	0.8	. . 4 .
121664	2903	Ursa Major	+64° 890	12 16 12	+64 14.0	8.3	9.0	0.7	2 3 . 5
122169	2904	Draco	+69° 663	12 21 49	+69 14.4	9.4	10.0	0.6	. . 4 .

REMARKS.

023765. Apparently of the Algol Type.
024462. Apparently of the Algol Type.
034658. Period apparently short.

113267. Period evidently very short.
113552. Apparently of the Algol Type.

EDWARD C. PICKERING.

APRIL 12, 1907.

HARVARD COLLEGE OBSERVATORY.

CIRCULAR 128.

MISSING DURCHMUSTERUNG STARS.

THE great number of facts contained in the Bonn Durchmusterung has rendered a large number of errors unavoidable, notwithstanding the careful supervision and revision of that work. The regular daily use of these catalogues and charts during the last twenty years, in the study of the Harvard collection of stellar photographs, particularly in the researches of the Henry Draper Memorial, has revealed many discrepancies. Nearly all of those given below have been found by Miss L. D. Wells. In some cases, the differences may be due to real changes in the star, and thus lead to the detection of variables, or stars having large proper motion. Some of these stars may be red, and thus fail to appear on the photographic plates. Table I contains a list of the stars which are either missing on the photographs, or at least two magnitudes fainter than the limiting magnitude of Durchmusterung stars in that part of the sky. They therefore would not have been visible in the telescope used in that work. So many stars are shown on the photographs, which are not contained in the Durchmusterung, that the discrepancies may fairly be ascribed either to errors, color, or variability. Should any of these stars hereafter be found to be as bright as their Durchmusterung magnitude would indicate, the dates of the photographs examined can readily be given. The Harvard collection of photographs would provide a means of determining the magnitudes on several hundred nights.

Several photographs were examined in each case. When an adjacent star was found, sufficiently bright to be included in the Durchmusterung but not contained in that work, its position is indicated in the last column of the table. Thus, such a star follows $+52^{\circ} 1172$, about $1^m.0$. A star is $12'$ north of $+14^{\circ} 2543$. In all such cases an examination of early and late plates showed that the deviation was not due to proper motion. The letter *f* in the same column denotes that a very faint star is present, and the letter *s* that, from the comparison of several plates, the star is faint, and suspected of variability.

The stars $+12^{\circ} 449$, $+24^{\circ} 531$, $+13^{\circ} 700$, $+13^{\circ} 703$, $+15^{\circ} 862$, $+32^{\circ} 1636$, $+21^{\circ} 2390$, $+14^{\circ} 2543$, and $+35^{\circ} 2385$, are marked with interrogation points

DM. No.	R.A. 1855.			Dec. 1855.	Mag.	Rem.	DM. No.	R.A. 1855.			Dec. 1855.	Mag.	Rem.		
	<i>h.</i>	<i>m.</i>	<i>s.</i>	<i>°</i>	<i>'</i>			<i>h.</i>	<i>m.</i>	<i>s.</i>	<i>°</i>	<i>'</i>			
+18° 2679	12	50	53.0	+18	30.2	9.5		+40° 4130	20	16	11.9	+40	4.7	9.5	f
+ 9° 2711	12	56	18.2	+ 9	44.5	9.4		+23° 4157	20	41	58.8	+23	30.6	9.2	
+29° 2366	12	59	28.0	+29	3.6	9.5	f	+17° 4475	20	51	42.2	+17	4.3	9.0	f
+24° 2732	14	19	0.4	+24	25.4	9.5	f	+15° 4337	21	0	28.1	+15	10.5	9.5	
+10° 2694	14	23	3.0	+10	5.3	9.5		+16° 4493	21	11	0.6	+16	9.5	9.5	f
+11° 2697	14	29	59.1	+11	38.8	9.5		+30° 4511	21	36	25.8	+30	14.3	9.5	f
+27° 2406	14	33	19.8	+27	29.8	9.5	+5'	+ 8° 4778	21	54	18.0	+ 8	17.5	9.5	
+10° 2813	15	7	27.3	+10	7.3	9.5	-3'	+26° 4331	21	55	12.1	+26	30.7	9.1	
+29° 2732	15	47	19.8	+29	7.9	9.5		+ 7° 4790	21	57	42.0	+ 7	5.3	9.0	
+25° 3033	16	1	47.3	+25	42.6	9.5		+25° 4711	22	12	59.0	+25	26.9	9.5	
- 0° 3110	16	17	20.2	- 0	52.8	9.5		+24° 4579	22	13	58.8	+24	35.0	9.5	+4'
+20° 3280	16	24	10.6	+20	55.7	9.5	+5'	+27° 4303	22	16	15.6	+27	3.8	9.4	-4'
+30° 2852	16	32	10.7	+30	51.9	9.5	-5'	+11° 4888	22	43	2.1	+11	12.5	9.5	
+ 7° 3353	17	15	54.8	+ 7	19.5	9.5		+19° 5013	22	43	29.0	+19	31.4	9.5	
-15° 4676	17	38	31.3	-15	5.5	9.1	s	+12° 4929	22	54	57.6	+12	12.6	9.5	
+12° 3353	17	53	6.6	+12	59.3	9.5		+43° 4563	23	44	25.9	+43	31.6	9.5	f
-17° 5349	18	42	58.2	-17	2.1	9.0	f	+47° 4317	23	47	51.3	+47	46.1	9.4	
+10° 4193	20	2	52.8	+10	24.0	9.5		+55° 3075	23	56	9.5	+55	2.8	9.5	-3'
+21° 4152	20	12	35.7	+21	47.8	9.4	+0 ^m .2								

JUPITER'S SIXTH SATELLITE.

Professor W. H. Pickering requests the publication of the following statement which he has prepared:—The error in the position of this body on Plate A 215, published in the Harvard Annals 60, 39, and first noticed and pointed out by Mr. Crommelin, was due, not to an error in identification of the satellite as might be gathered from Appendix II to that volume, but to the fact that owing to a misunderstanding a faint star or defect was measured on this plate instead of the object designated.—W. H. PICKERING.

DUPLICATING COMETARY ORBITS.

THE interest in comets, at present felt by astronomers, is well illustrated by the comet recently discovered by Giacobini. It was found on Saturday evening, March 9, 1907. No observations were secured on Sunday, but it was again observed on Monday and Tuesday. On Thursday morning three orbits were received here, of which, according to our rule, messages in cipher of the first only were distributed by telegraph. Neostyle copies of all three, after translation, were

distributed at once by first-class mail. A fourth orbit was published later in the *Nachrichten*, but not cabled here. The four sets of elements were substantially the same, since all depended on nearly the same observations. This needless duplication of computation is unfortunate, since similar work in computing the orbits of newly discovered asteroids is much needed. It is hoped that some arrangement may be made by the computers of cometary orbits, either to take them in turn to compute more accurate orbits using longer intervals, or to undertake instead the computation of orbits of asteroids. This is now of special importance owing to the large number of asteroids which are being discovered by the Rev. Joel H. Metcalf of Taunton, Mass. It is hoped that computers will communicate with him, as, if such orbits are not computed promptly, these objects, some of which may prove of special importance, may be lost for want of an ephemeris. The interest in a comet is generally only temporary, while the laws regulating the paths of asteroids like Eros and TG may have the greatest permanent value.

EDWARD C. PICKERING.

APRIL 26, 1907.

HARVARD COLLEGE OBSERVATORY.

CIRCULAR 129.

15 NEW VARIABLE STARS IN HARVARD MAPS Nos. 31 AND 62.

CIRCULAR 127 contains a description of a search for variables in all parts of the sky, according to a uniform system, and the results derived from the regions of the Harvard Map of the Sky, Nos. 3 and 6. A similar study of No. 31, by Miss Annie J. Cannon, is contained in the present circular. A preliminary and incomplete study was also made of the region whose centre is in R.A. 1^h , Dec. $+45^\circ$, before the division of the work, adopted later, had been made. This region will be designated as No. 62, since this will be its number in the second map of the sky, in which the centres of the plates alternate with those of the first map, the centres of one set, in general, coinciding with the corners of the other.

Of the fifteen new variable stars given in Table I, the first and last were found in region No. 62, and the other thirteen in No. 31.

In No. 62, the known variables, 000451, T Cassiopeiae, V Andromedae, RV Cassiopeiae, RW Cassiopeiae, Y Andromedae, U Persei, and V Cassiopeiae were also found. No. 31 contains 28 known variables brighter than magnitude 11 at maximum, of which Z Ophiuchi, RV Ophiuchi, RY Herculis, RY Ophiuchi, T Serpentis, X Ophiuchi, R Scuti, and R Aquilae were also found. If we assume that the number of known variables found is to the total number found, as the number already known is to the whole number existing in the region, it follows that there are probably 73 variable stars in this region, of which only 41, or about 0.56 have so far been discovered. It is evident that an examination of additional plates of this region would be profitable.

The successive columns of Table I give the designation, the Harvard number, the constellation, the number in the Bonn Durchmusterung, the right ascension for 1900, the declination for 1900, the brightest observed photographic magnitude, the faintest observed photographic magnitude, the range, and the class to which the variable belongs. The facts which have so far been collected relating to these stars are given in the Remarks following Table I. The variability of all these objects has been confirmed either by a second observer, or

by examination of a sufficient number of photographs to establish the variability beyond question. Several stars were suspected of variability and showed an apparent change of about 0.5 magnitude on the photographs. They are not included in the following list, however, but have been reserved until further evidence of real variability can be secured.

TABLE I.
NEW VARIABLE STARS.

Design.	Harvard No.	Constellation.	DM. No.	R. A. 1900.			Dec. 1900.	Br.	Ft.	Range.	Class.
				<i>h.</i>	<i>m.</i>	<i>s.</i>	<i>°</i>				
012746	2905	Andromeda	..	1	27	34	+46 0.4	9.2	<11.5	>2.3	II
172801	2906	Ophiuchus	..	17	28	50	- 1 0.4	10.0	11.1	1.1	IV
173401	2907	Ophiuchus	..	17	34	22	+ 1 39.8	10.0	11.0	1.0	IV
175103	2908	Ophiuchus	..	17	51	25	+ 3 24.1	9.7	<12.0	>2.3	II
180415	2909	Serpens	-15° 4842	18	4	7	-15 33.8	8.5	10.0	1.5	V
181813	2910	Scutum	-13° 4965	18	18	54	-13 42.6	9.3	10.4	1.1	V
182513	2911	Scutum	-13° 5014	18	25	41	-13 10.9	9.5	11.0	1.5	IV
183208	2912	Scutum	- 8° 4663	18	32	36	- 8 27.3	8.9	10.2	1.3	IV
183604	2913	Scutum	- 4° 4553	18	36	40	- 4 12.6	9.1	10.2	1.1	IV
183606	2914	Ophiuchus	..	18	36	49	+ 6 19.6	10.6	11.4	0.8	..
183705	2915	Scutum	- 5° 4734	18	37	36	- 5 55.9	9.0	10.3	1.3	IV
184310	2916	Scutum	-10° 4814	18	43	40	-10 21.0	8.9	9.8	0.9	IV
185901	2917	Aquila	+ 1° 3877	18	59	35	+ 1 9.1	8.8	10.5	1.7	IV
190301	2918	Aquila	+ 1° 3899	19	3	10	+ 1 8.7	7.6	9.0	1.4	IV
230258	2919	Cassiopeia	..	23	2	53	+58 1.0	9.2	10.2	1.0	IV

REMARKS.

012746. This star has been observed on 50 photographs, taken between November 2, 1892 and February 15, 1907. These observations are satisfactorily represented by the formula for times of maximum, $J. D. 2412486 + 337 E$. The range of variation is probably greater than that indicated by the photographic magnitudes given in the table. Miss Cannon looked for this object with the 6-inch Equatorial of this Observatory, on March 6, 1907 and April 2, 1907. On the first date, the star was barely glimpsed in a clear sky, and estimated as about magnitude 13. On the second date, it was not seen and estimated as certainly fainter than magnitude 12.5. These observations are in agreement with the elements given above, according to which the next maximum will occur on October 29, 1907.

172801. Observations of this star have been made on 31 photographs, taken between July 19, 1893 and August

4, 1904. The period is short. The rise to maximum is rapid, since on Plate B 33655 taken at Arequipa on May 5, 1904, $18^h 35^m$ G. M. T., the star is at minimum, about magnitude 11.1, while on Plate AM 2619, taken at Arequipa on May 5, 1904, $20^h 17^m$ G. M. T., the star is at maximum, and at least one magnitude brighter than on the earlier plate. On May 6, 1904, $19^h 43^m$ G. M. T., the star was also at maximum. The period is probably about one day or a divisor thereof.

173401. This star has been observed on 30 photographs, taken between April 11, 1900 and September 12, 1904. At maximum, it is as bright photographically as $+ 1^{\circ} 3476$, magnitude 9.4. At minimum, it is about one magnitude fainter. To gain some idea of the period and nature of the variation, a series of plates taken from May to September, 1904, was examined. The variable was at maximum on May 3, May 5, May 6, May 7, May 21, August 18, and September 1, 1904,

- and at minimum or fainter than normal, on June 18, June 20, July 1, July 14, July 21, and July 30 1904. The period is therefore short.
175103. Observations have been made of this star on 42 photographs, taken between July 11, 1893 and April 21, 1907. These observations are satisfactorily represented by the formula for times of maximum, J. D. 2414862 + 216 E.
180415. This is a variable star of the Algol type. It has been observed on 366 photographs, taken between March 1, 1888 and October 20, 1906. The approximate period, $14^d.15$, has been derived from a preliminary study of these observations, of which a complete discussion has not yet been made.
181813. This is a variable star, apparently of the Algol type. It is of normal magnitude on 100 photographs out of 120 which were examined. Photographs taken on July 5, 1901, July 14, 1903, June 7, June 17, August 18, September 28, 1904, April 21, and October 21, 1905, show the object at or near minimum.
182513. This star has been observed on 35 photographs, taken between March 9, 1888 and June 12, 1906. The period is short. On a plate taken June 3, 1904, $17^h 23^m$ G. M. T., the star is at maximum, while on June 4, 1904, $18^h 24^m$ G. M. T., the star is more than one magnitude fainter. The star was also faint on June 17, 1904, about $17^h 00^m$ G. M. T., and on June 18, 1904, about $16^h 59^m$ G. M. T.
183208. Observations of this star have been made on 23 photographs, taken between August 25, 1902 and June 12, 1906. The observations show that the period is not greater than ten days, and it may be much less.
183604. Observations of this star have been made on 25 photographs, taken between August 25, 1902 and June 12, 1906. The period is short.
183606. This star has been observed on 32 photographs taken between July 16, 1893 and July 22, 1905. The observations so far obtained do not determine the nature of the variation. The period may be irregular.
183705. This star has been observed on 20 photographs, taken between August 25, 1902 and June 12, 1906. The period is short, and apparently does not exceed four days.
184310. This star has been observed on 39 photographs, taken between June 10, 1892 and July 22, 1905. It was at first thought to be of the Algol type, Class V, but later observations make it more probable that it belongs to Class IV.
185901. This star has been observed on 512 photographs, taken between May 22, 1888 and November 9, 1906. The observations are fairly well represented by the provisional elements for times of maximum, J. D. 2412685.63 + $17^d.132$ E. This star is No. 6507 in the Catalog der Astron. Gesell., Vol. 14, where its magnitude is given as 8.5. This magnitude depends on observations by Boss at the Dudley Observatory on August 7, and August 12, 1880. According to the elements given above, a maximum occurred on August 12, 1880. As shown on about thirty photographs, the change is slow at the time of maximum, and the star probably remains bright for at least two days.
190301. This star has been observed on 506 photographs, taken between May 22, 1888 and November 9, 1906. The provisional elements for times of maximum, J. D. 2411873.865 + $13^d.75$ E, have been derived from a preliminary study of these observations. The spectrum appears to change. At maximum, it is of Class G, and the distribution of the light is even from the bands H and K to the line $H\beta$. At or near minimum, the spectrum resembles Class K, and the portion of the spectrum from $H\epsilon$ to $H\gamma$ has become much fainter than the portion from $H\gamma$ to $H\beta$. It thus appears as if the variation may be due to a diminution in the rays of shorter wave length.
230258. Observations of this star have been made on 24 photographs, taken between August 8, 1899 and December 19, 1906. The period appears to be about five days. At maximum, this star is as bright as +57° 2694, magnitude 9.2. At minimum, it becomes at least one magnitude fainter.

IDENTIFICATION OF ASTEROIDS.

When an asteroid is discovered, the only means of determining whether it is new or already known, is ordinarily by the positions at opposition given in the Berlin Jahrbuch. Ephemerides for forty days, at intervals of two days are given each year in the Veröff. des Königl., Astron. Rechen-Instituts for a number of asteroids. No. 31 of the latter work contains ephemerides of 38 asteroids, coming to opposition during 1907. The greater portion of these agree closely with the positions given in the Jahrbuch, but in a few cases the difference is so great that it would be difficult to find or identify the asteroid even by

photography. For the convenience of observers a list of those in which the positions at opposition differ by more than a minute of time, is given in Table II. The successive columns contain the number and name of the asteroid, the date of opposition, and the right ascension and declination on this date, according to the Jahrbuch. The following columns give, for this same day, the right ascension and declination according to the Rechen-Instituts, the Jahrbuch minus Rechen-Instituts positions, and the date of opposition according to the Rechen-Instituts.

Ephemerides are given by the Rechen-Instituts for (583), 1905 SP, and (411), 1896 CJ, whose positions are not given in the Jahrbuch. The latter is erroneously called CT by the Rechen-Instituts.

TABLE II.
DISCORDANT POSITIONS.

Des.	Name.	Jahrbuch.			Rechen.			J — R.		Opp. R.
		Opp.	R.A.	Dec.	R.A.	Dec.	R.A.	Dec.		
			<i>h. m.</i>	<i>° ′</i>	<i>h. m.</i>	<i>° ′</i>	<i>m.</i>	<i>′</i>		
475	Oello	Jan. 14	7 44.3	+48 6	7 28.4	+48 25	+15.9	— 19	Jan. 12	
509	Iolanda	“ 23	8 19.2	— 5 26	8 23.5	— 3 20	— 4.3	—126	“ 22	
331	Etheridgea	March 4	10 58.9	+12 44	10 57.5	+12 52	+ 1.4	— 8	March 5	
365	Corduba	“ 17	11 45.1	— 1 38	11 42.9	— 1 31	+ 2.2	— 7	“ 17	
488	Kreusa	April 3	12 46.8	+13 35	12 9.8	+18 29	+37.0	+ 6	“ 25	
86	Semele	May 10	15 8.8	—13 20	15 5.8	—13 4	+ 3.0	— 16	May 9	
522	Helga	June 10	17 9.9	—18 39	.. ..	.. ..	..	..	July 3	

The true position of (488) Kreusa is nearly that given by the Rechen-Instituts. The positions of (522) Helga, in the two tables, differ by more than an hour. The ephemeris of the Rechen-Instituts only extends from June 21 to July 31.

EDWARD C. PICKERING.

MAY 10, 1907.

HARVARD COLLEGE OBSERVATORY.

CIRCULAR 130.

71 NEW VARIABLE STARS IN HARVARD MAPS Nos. 9, 12, 21, 48, AND 51.

IN continuation of the systematic search for variables in all parts of the sky, as described in Circulars 127 and 129, five additional regions have been examined by Miss Leavitt. The positions of these regions and some of the principal results are given in Table I. The number of the plate in the Map of the Sky, Circular 71, and the right ascension and declination of its centre, are contained in the first two columns. The third, fourth, and fifth columns give the number of new variables discovered, the total number found in this examination, including known variables, and the proportion of new variables. The number known to exist in the region at the close of the examination is given in the sixth column. This includes all previously known variables as bright at maximum as the magnitude 10.5 and within 15° of the centre of the region, with one exception given below. Novæ discovered earlier than 1900, and suspected variables, are omitted. The number previously known may be found by subtracting the number given in the third column from that in the sixth. The seventh column gives the probable number of variables in the region, assuming that the number of known variables found

TABLE I.

NUMBER AND DISTRIBUTION OF THE VARIABLES.

No.	Region.	New Variables.	Total Found.	Proportion New.	All.	Probable Number.	Proportion Found.	Probable No. Unknown.	Proportion Unknown.
	<i>h.</i> <i>°</i>								
9	21 +60	11	16	.69	21	32	.50	11	.39
12	4 +30	9	16	.51	28	43	.37	15	.35
21	22 +30	8	15	.53	25	36	.42	11	.31
48	6 -60	13	16	.81	22	48	.33	26	.54
51	15 -60	30	42	.72	65	122	.34	57	.47

is to the total number found as the number previously known is to the whole number in the region. The eighth column gives the proportion of the probable number which was actually found. The ninth and tenth columns give the probable number remaining undiscovered, and the proportion of these to the assumed total given in the seventh column. The plates examined for region 9 were poor in the southern part, and only very conspicuous variables could be found south of $+48^\circ$. Seven known variables, between $+45^\circ$ and $+48^\circ$, have been omitted, therefore, and the region discussed in Table I extends southward from the centre 12° instead of 15° .

The following known variables were re-discovered:—In Region 9, RT Cygni, T Cephei, RU Cygni, 220550, and δ Cephei. In Region 12, U Arietis, R Persei, Nova Persei No. 2, RW Persei, RV Tauri, RX Aurigae, and RW Aurigae. In Region 21, VY Cygni, SS Cygni, RR Pegasi, WY Cygni, VZ Cygni, 215122, and 220134. In Region 48, R Doradus, R Pictoris, and S Pictoris. In Region 51, 130763, 133357, 134459, R Centauri, 145254, 150469, R Trianguli Australis, R Normae, U Normae, S Trianguli Australis, U Trianguli Australis, and W Normae. The activity now prevailing in the search for new variables is shown by the fact that 8 out of these 34 variables have been announced since January 1, 1906, and another, 220134, recently discovered by Mrs. Fleming, has not yet been announced.

The new variables are given in Table II, in which the successive columns give the designation, Harvard number, constellation, number in the Bonn Durchmusterung or the Cape Photographic Durchmusterung, brightest and faintest magnitudes observed, and range.

Variables 050253, 133664, 142950, 144355, 152157, 192668, 205027, 220045, 222317, and probably 050845, 135251, 150554, and 164461 appear to be of the Algol type. Many of the periods are probably short. The following stars probably vary in long periods: 041528, 043163, 044460, 050964, 060659, 124868, and 215927. The proportion of Algol variables is remarkable, as was the case in Region 50, discussed in Circular 122.

It appears from the last column of Table I, that about a third of the variables in the three northern regions and about half of those in the two southern regions, remain to be discovered. A number of the new variables are brighter than the eighth magnitude, or have a large range. While the southern regions of the sky contain a relatively large proportion of undiscovered variables, it is evident that abundant opportunity remains for interesting research in regions accessible to American and European observers.

TABLE II.
NEW VARIABLES.

Design.	Harvard No.	Constellation.	DM. No.	R. A. 1900.			Dec. 1900.		Bright.	Faint.	Range.
				<i>h.</i>	<i>m.</i>	<i>s.</i>	<i>°</i>	<i>'</i>			
025338	2920	Perseus	+38° 606	2	53	42	+38	47.7	8.5	10.5	2.0
041041	2921	Perseus	.. ..	4	10	12	+41	29.2	10.2	11.0	0.8
041528	2922	Taurus	+28° 645	4	15	43	+28	12.9	9.6	10.6	1.0
043018	2923	Taurus	+18° 659	4	30	44	+18	33.8	10.0	10.6	0.6
043163	2924	Reticulum	-63° 341	4	31	36	-63	11.9	8.8	<11.5	>2.7
044242	2925	Perseus	+42° 1064	4	42	45	+42	7.0	8.5	9.8	1.3
044460	2926	Dorado	.. ..	4	43	58	-59	59.5	8.8	<11.5	>2.7
044750	2927	Pictor	.. ..	4	47	36	-50	49.6	10.0	11.5	1.5
044930	2928	Auriga	+30° 743	4	49	36	+30	24.4	8.6	9.6	1.0
050253	2929	Pictor	-53° 791	5	2	43	-53	16.6	9.4	10.5	1.1
050239	2930	Auriga	+39° 1192	5	2	47	+39	27.7	8.0	9.4	1.1
050442	2931	Auriga	+41° 1101	5	4	38	+42	2.0	7.4	8.0	0.6
050542	2932	Auriga	+42° 1201	5	5	31	+42	42.7	9.0	10.0	1.0
050845	2933	Pictor	-45° 579	5	8	17	-45	41.9	9.0	10.0	1.0
050964	2934	Dorado	.. ..	5	9	35	-64	26.5	9.1	<11.5	>2.4
054675	2935	Mensa	-75° 333	5	46	2	-75	17.3	9.5	10.6	1.1
060650	2936	Puppis	-50° 913	6	6	53	-50	11.2	9.0	<11.0	>2.0
061259	2937	Pictor	-59° 613	6	11	58	-59	53.2	9.2	11.0	1.8
062960	2938	Pictor	.. ..	6	29	1	-60	9.2	10.0	10.8	0.8
063455	2939	Carina	.. ..	6	34	23	-55	46.7	9.5	10.5	1.0
063852	2940	Carina	-52° 979	6	38	36	-52	20.2	8.8	9.5	0.7
070558	2941	Carina	-58° 848	7	5	7	-58	13.3	8.2	9.3	1.1
124868	2942	Musca	-68° 1793	12	48	46	-68	21.8	9.4	10.0	0.6
125763b	2943	Centaurus	-63° 2507	12	57	33	-63	33.7	9.8	10.5	0.7
131062	2944	Centaurus	-61° 3558	13	10	45	-62	5.8	10.2	11.0	0.8
131261	2945	Centaurus	-61° 3585	13	12	28	-61	51.3	9.2	10.0	0.8
133664	2946	Circinus	-64° 2524	13	36	15	-64	58.2	10.0	11.0	1.0
134457	2947	Centaurus	-56° 5960	13	44	2	-57	5.2	7.8	8.6	0.8
135155	2948	Centaurus	-55° 5802	13	51	34	-55	51.9	9.8	10.5	0.7
135251	2949	Centaurus	-51° 6466	13	52	0	-51	15.5	9.9	10.6	0.7
140753	2950	Centaurus	-53° 5915	14	7	22	-53	27.7	9.6	10.5	0.9
142448	2951	Lupus	-48° 6504	14	24	7	-48	14.6	10.5	11.5	1.0
142760	2952	Centaurus	-60° 5432	14	27	16	-60	31.4	8.7	9.3	0.6
142950	2953	Lupus	-50° 7071	14	29	45	-50	58.6	10.3	11.1	0.8
144059	2954	Circinus	.. ..	14	40	31	-59	35.0	9.5	15.0	5.5
144048	2955	Lupus	-48° 6778	14	40	46	-48	54.0	9.8	10.5	0.7
144355	2956	Circinus	-55° 6204	14	43	48	-55	30.2	9.8	10.6	0.8
144868	2957	Triang. Aust.	-68° 2226	14	48	1	-68	25.9	8.7	9.5	0.8
145571	2958	Apus	-71° 1717	14	54	59	-71	12.7	10.5	11.5	1.0
150554	2959	Norma	-54° 6379	15	5	4	-54	56.1	9.5	10.5	1.0
150970	2960	Apus	-70° 2005	15	9	39	-70	50.8	10.5	11.3	0.8

Design.	Harvard No.	Constellation.	DM. No.	R. A. 1900.			Dec. 1900.		Bright.	Faint.	Range.
				<i>h.</i>	<i>m.</i>	<i>s.</i>	<i>°</i>	<i>'</i>			
152157	2961	Circinus	.. ..	15	21	24	-57	43.7	10.0	11.4	1.4
153365	2962	Triang. Aust.	-65° 3122	15	33	32	-65	36.1	9.7	10.5	0.8
155344	2963	Norma	-44° 7719	15	53	14	-44	50.5	8.6	9.3	0.7
155753	2964	Norma	-53° 7039	15	57	24	-53	38.5	10.0	11.0	1.0
160561	2965	Triang. Aust.	.. ..	16	5	17	-61	50.2	9.8	<11.5	>1.7
164360	2966	Ara	.. ..	16	43	35	-60	54.4	10.3	11.1	0.8
164461	2967	Ara	-61° 5799	16	44	37	-61	25.0	10.0	10.6	0.6
164565	2968	Triang. Aust.	-64° 3573	16	45	4	-65	2.3	9.5	11.5	2.0
164863	2969	Ara	-63° 4037	16	48	23	-63	2.9	9.2	10.0	0.8
165161	2970	Ara	-61° 5820	16	51	36	-61	15.7	9.2	10.0	0.8
190965	2971	Draco	+65° 1327	19	9	44	+65	56.6	8.9	9.8	0.9
192668	2972	Draco	+68° 1065	19	26	9	+68	43.7	9.3	10.0	0.7
193056	2973	Cygnus	+56° 2257	19	30	22	+56	10.8	8.8	9.8	1.0
200949	2974	Cygnus	+49° 3225	20	9	52	+49	9.0	9.2	10.0	0.8
205027	2975	Vulpecula	+27° 3914	20	50	31	+27	32.3	9.0	10.2	1.2
213231	2976	Cygnus	+31° 4504	21	32	15	+31	39.1	7.3	8.3	1.0
214356	2977	Cepheus	+56° 2642	21	43	26	+56	49.9	9.2	9.8	0.6
215927	2978	Pegasus	+27° 4243	21	59	28	+27	51.6	7.2	7.8	0.6
220045	2979	Lacerta	+45° 3782	22	0	43	+45	56.2	8.4	9.2	0.8
220445	2980	Lacerta	+45° 3813	22	4	39	+45	15.0	7.	..	0.6
221453	2981	Lacerta	.. ..	22	14	11	+53	57.7	9.5	10.2	0.7
221955	2982	Cepheus	+55° 2737	22	19	22	+55	27.6	8.2	8.8	0.6
222317	2983	Pegasus	+17° 4753	22	23	44	+17	30.9	10.0	11.0	1.0
222924	2984	Pegasus	.. ..	22	29	14	+24	2.5	9.5	<11.0	>1.5
223564	2985	Cepheus	+64° 1694	22	35	42	+64	19.3	8.6	9.3	0.7
223656	2986	Lacerta	+56° 2829	22	36	54	+56	18.6	8.3	9.0	0.7
223755	2987	Lacerta	+55° 2789	22	37	27	+55	54.6	8.8	9.6	0.8
224029	2988	Pegasus	+29° 4745	22	40	2	+29	45.6	10.0	11.0	1.0
224426	2989	Pegasus	+26° 4507	22	44	18	+26	49.8	8.8	9.6	0.8

REMARKS.

124868. Suspected during the examination of region 50, described in Circular 122, but the range observed at that time was small.

144059. This star is brighter than the twelfth magnitude on all plates taken in 1906. The dates are as follows: February 14 and 17, March 24 and 27, April 24, May 10, 12, and 14, June 9, 13, 15, and 27, July 10, 13, and 24, August 24. The light gradually diminished, with some fluctuations, from the magnitude 9.5 in February to the magnitude 11.6 in August. On 55 plates taken between 1889 and 1905, the star was not seen and was fainter than the

thirteenth magnitude. A fifteenth magnitude star which is probably in the same position is seen on seven early plates of long exposure. The image is not sufficiently well-defined on these plates to determine whether there is variation. The object is probably a Nova. Its magnitude and the time of its appearance are nearly the same as in the case of Nova Velorum, announced in Circular 121.

220445. This variable is difficult to observe, on account of its brightness. Confirmed photometrically by Professor Wendell, with a range of 0.3 magn.

EDWARD C. PICKERING.

JULY 13, 1907.

HARVARD COLLEGE OBSERVATORY.

CIRCULAR 131.

GROUP OF RED STARS NEAR NOVA VELORUM.

IN a cursory examination of Draper Memorial spectrum plates, recently received from Peru, a new gaseous nebula was found, by Mrs. Fleming, on Plate A 8341, taken with the 24-inch Bruce Telescope, on June 6, 1907, with an exposure of 120^m. On further examination this object proved to be the spectrum of Nova Velorum, the new star discovered by Miss H. S. Leavitt, and announced in H. C. 121. The region covered by Plate A 8431, R. A. 10^h 36^m to 11^h 23^m, Dec. -51°.0 to -57°.0 (1875) shows so many interesting spectra that a list of them has been prepared, and is given in Table I. All of these are here

TABLE I.

RED STARS IN REGION OF NOVA VELORUM.

C. P. D.	R. A. 1875.	Dec. 1875.	Mag.	Spectrum.	C. P. D.	R. A. 1875.	Dec. 1875.	Mag.	Spectrum.
	<i>h. m. s.</i>	<i>° ' "</i>				<i>h. m. s.</i>	<i>° ' "</i>		
-53° 4068	10 37 2.2	-53 4.1	9.8	Mb5c	-53° 4299	10 57 11.7	-53 53.6	10.0	Mb
-52° 3863	10 38 59.6	-52 26.2	9.2	Mb5c	-51° 3819	10 58 40.5	-51 48.0	9.6	Ma5b
-52° 3887	10 40 33.6	-52 58.3	8.7	Ma	.. ..	10 57 15.9	-53 42.8	..	Br. lines
-54° 4020	10 40 44.3	-54 4.2	9.6	Mb	-55° 4114	10 59 39.8	-55 25.2	9.5	Mb
-52° 3915	10 42 21.6	-52 41.8	10.0	Mb	.. ..	11 1 45.3	-53 45.8	..	Mb
-55° 3855	10 42 47.7	-55 0.0	10.0	Mb	-53° 4358	11 1 54.8	-53 11.6	9.4	Mb
-55° 3876	10 43 55.2	-55 56.6	9.6	Mb5c	R	11 1 50.8	-54 26.8	9.0	Na
-54° 4080	10 44 42.3	-54 11.8	9.6	Ma	-52° 4239	11 2 27.7	-52 7.7	8.9	Ma
-52° 3964	10 45 59.5	-52 54.8	10.0	Mb	-55° 4157	11 3 3.8	-55 19.8	9.8	Mb
-55° 3919	10 46 25.1	-55 3.5	10.1	Mb	-55 4176	11 4 18.3	-55 20.8	10.0	Mb
-56° 3935	10 47 1.7	-56 15.6	9.6	Mb	-52° 4310	11 6 2.2	-52 49.4	9.4	Ma
.. ..	10 47 35.2	-52 45.6	..	Na	-55° 4207	11 6 45.8	-55 32.1	9.6	Mb
.. ..	10 49 45.7	-53 26.2	..	Ma	-54° 4389	11 7 12.5	-54 17.4	9.6	Ma
-52° 4048	10 52 0.0	-52 26.7	10.2	Mc	-54° 4405	11 8 30.8	-54 10.7	9.8	Ma5b
-56° 4069	10 54 11.2	-56 5.3	9.4	Mb	-53° 4500	11 15 43.0	-53 26.9	9.6	Ma?
-55° 4046	10 55 1.0	-55 10.5	9.2	Ma	.. ..	11 15 42.2	-55 4.8	..	Na
-55° 4075	10 56 50.6	-55 14.4	9.3	Mb	-54° 4516	11 18 39.9	-54 27.1	9.4	Ma5b

announced for the first time, unless otherwise stated in the Remarks. The designation and magnitude taken from the Cape Photographic Durchmusterung are given in the first and fourth columns, the right ascension and declination for 1875, in the second and third columns. The class of spectrum is given in the fifth column. Two of these stars have been found to be variable, and one other, suspected of variability, proved to be the known variable, R W Centauri.

REMARKS.

- | | |
|---|---|
| <p>10^h 47^m 35^s.2. H. V. 2990. An examination of 10 chart plates, taken between June 20, 1900 and May 13, 1905, shows a variation of about 0.9 magn. Estimates from these plates give the approximate limiting magnitudes, 10.0 to 10.9. A plate taken on April 12, 1898, gives the estimated magnitude 12.0, and increases the amount of variation to about 2.0 magnitudes.</p> <p>10^h 57^m 15^s.9. H. V. 1268. Nova Velorum. Seven bright lines appear in this spectrum, having the approximate wave-lengths, 5013, 4926, 4862, 4643, 4611, 4340, and 4101. Their estimated intensities are 7, 3, 2, 4, 4, 10, and 1, respectively. All of these lines appear to coincide with bright lines in</p> | <p>the later spectra of Nova Persei, No. 2, except the fifth, 4611, which perhaps coincides with a bright line at 4608 in the spectrum of H. P. 1311. The strong helium line, 4472, however, which was bright in Nova Persei, No. 2, is absent.</p> <p>11^h 1^m 50^s.S. The known variable star, RW Centauri. Rediscovered independently in this examination. This star is Z. C. 11^h 129.</p> <p>11^h 15^m 42^s.2. H. V. 2991. An examination of 11 chart plates, taken between April 12, 1898 and May 13, 1905, shows a variation of about 0.7 magn. Estimates from these plates give the approximate limiting magnitudes, 9.7 to 10.4.</p> |
|---|---|

The variable stars, 104055 = H 1275, and 110551 = H 1281, found by Miss Leavitt, and announced in H. C. 122, have spectra of Classes K and A 5 F, respectively, on Plate A 8341.

EDWARD C. PICKERING.

OCTOBER 3, 1907.

HARVARD COLLEGE OBSERVATORY.

CIRCULAR 132.

STARS HAVING PECULIAR SPECTRA. 15 NEW VARIABLE STARS.

AN examination of the photographs of the Henry Draper Memorial, by Mrs. Fleming, has led to the discovery of a number of variable stars and other objects having peculiar spectra. A list of these is given in Table I. The constellation and Durchmusterung number are given in the first two columns. The approximate right ascension and declination for 1900 and the catalogue magnitude are given in the third, fourth, and fifth columns. The designations for stars north of declination -23° are taken from the Bonn Durchmusterung. For stars between -23° and -52° the Cordoba Durchmusterung, and for stars south of declination -52° the Cape Photographic Durchmusterung is used. The class of spectrum and a brief description of the object are given in the sixth and seventh columns. Each of the new variables has been confirmed by Miss L. D. Wells, unless otherwise specified. Additional information regarding these objects is given in the Remarks following the table. In the case of new variable stars, the right ascension is followed by the designation, described in H. A. 48, 93, which gives the approximate position, and also the designation described in H. A. 53, 147, which indicates the number in the series of variables found at Harvard. This last number is also given in the table, for convenience of future reference.

The star $+66^\circ$ 780 is given by Dunér and by Krüger as of the fourth type. It was announced as a variable star in H. C. 124. The spectrum appears to change on the photographs available for examination. On Plate I 3247, taken on March 5, 1891, the spectrum is faint but clearly shown and contains no bright line. On Plate I 12509, taken on March 14, 1895, the object is near the edge of the plate. No part of the continuous spectrum is visible, but the bright line $H\beta$ is well defined and easily seen. On Plate I 12724, taken on April 19, 1895, the line $H\beta$ appears as a strong bright line, and the portion of the continuous spectrum shown is of shorter wave length than $H\beta$ and does not extend beyond $H\gamma$. On Plate I 33878, taken on February 22, 1906, the line $H\beta$ appears as a strong bright line, and the brightest and best defined portion of the spectrum is of greater wave length than $H\beta$, but the portion between $H\beta$ and $H\gamma$ is also well shown, although about half a magnitude fainter than the part of greater wave length

TABLE I.
PECULIAR SPECTRA.

Constellation.	DM.	R. A. 1900.		Dec. 1900.		Magn.	Spectrum.	Description.
		<i>h.</i>	<i>m.</i>	<i>°</i>	<i>'</i>			
Aries	+11° 305	2	9.6	+11	46	8.9	Pec.	Variable?
Auriga	+45° 1324	6	28.2	+45	43	8.7	Mc	Variable. H 2992.
Monoceros	- 4° 1708	6	48.3	- 4	27	9.0	Na	Variable. H 2993.
Canis Major	-22° 1850	7	19.4	-22	47	9.1	Na	Variable. H 2994.
Cancer	+15° 1808	8	16.8	+15	19	8.6	Mc 5 d	Variable. H 2995.
Ursa Major	. .	9	44.4	+53	7	. .	Pec.	Dark bands.
Vela	-49° 5234	10	21.0	-49	54	9.6	Pec.	Dark bands.
Carina	-72° 1048	10	48.7	-72	14	9.8	Mb 5 c	Variable. H 2996.
Musca	R	11	35.0	-72	0	8.5	Na	Variable. H 2997.
Virgo	. .	12	0.0	+12	56	. .	Md	Variable. H 2998.
Musca	R	12	17.4	-74	57	9.5	Na	Variable. H 2999.
Corvus	-16° 3503	12	32.3	-16	43	9.6	Mc 5 d	Variable. H 3000.
Centaurus	-63° 2720	13	15.5	-63	42	9.5	Na	Variable. H 3001.
Centaurus	-56° 5891	13	36.4	-56	16	6.8	Pec.	Class A, peculiar.
Circinus	-67° 2622	14	30.9	-67	46	7.0	Pec.	H β bright.
Corona Borealis	+39° 2901	15	37.8	+38	53	7.0	Mc 5 d	Variable. H 3002.
Draco	+57° 1786	17	35.4	+57	48	9.3	Mc 5 d	Variable. H 3003.
Ophiuchus	+ 6° 3898	18	37.1	+ 6	43	9.0	Pec.	Dark bands.
Aquila	. .	20	7.1	+11	35	. .	Pec.	Bright line. Type V.
Draco	+74° 861	20	25.9	+74	56	9.3	Mc 5 d	Variable. H 3004.
Cygnus	+32° 3850	20	27.6	+32	14	9.1	Na	Variable. H 3005.
Pegasus	+34° 4597	22	1.4	+34	52	8.5	Mc 5 d	Variable. H 3006.
Aquarius	-21° 6376	23	6.3	-21	32	9.0	Pec.	Dark bands.

REMARKS.

h. m.

2 9.6. An examination of twenty-four chart plates, taken between January 13, 1890 and September 6, 1905, shows a small but distinct variation in the light of this star. On several plates it is about 0.2 magnitude fainter than +11° 303, magn. 9.5, (assumed photographic magnitude 8.6), while on others it is about 0.3 to 0.4 magnitude brighter than that star. Estimates from these plates gave the approximate limiting magnitudes, 8.2 to 8.8.

6 28.2. 062845 = H. V. 2992. An examination of this star on twenty-one chart plates, taken between March 3, 1890 and March 11, 1905, shows a variation of about 0.9 magn. Estimates from these plates gave the approximate limiting magnitudes, 8.5 to 9.4.

6 48.3. 020911 = H. V. 2993. The spectrum of this star is already known as Type IV. An examination of sixteen chart plates of this object, taken between February 22, 1891 and November 11, 1904, shows a variation

h. m.

of about 1.2 magn. Estimates from these plates gave the approximate limiting magnitudes, 9.2 to 10.4.

7 19.4. 071922 = H. V. 2994. An examination of this star on twenty-one chart plates, taken between April 17, 1894 and November 30, 1904, shows a decided although small variation of 0.9 magn. Estimates from these plates gave the approximate limiting magnitudes, 11.0 to 11.9.

8 16.8. 081615 = H. V. 2995. An examination of this star on eighteen chart plates, taken between February 14, 1899 and January 30, 1906, shows a variation of about 0.9 magn. Estimates from these plates gave the approximate limiting magnitudes, 9.4 to 10.3.

9 44.4. This spectrum is faint, but is apparently of the same type as C.DM. -47° 6614, described in H.C. 76.

10 21.0. This spectrum is of the same type as C.DM. -47° 6614, described in H.C. 76.

10 48.7. 104872 = H. V. 2996. An examination of this star on eighteen chart plates, taken between April 1,

- h. m.*
 1890 and May 12, 1905, shows a variation of about 1.7 magn. Estimates from these plates gave the approximate limiting magnitudes, 9.8 to 11.5.
- 11 35.0. 113572 = H.V. 2997. This star is A.G.C. 15946 and is known to have a spectrum of Type IV. An examination of eighteen chart plates of this object, taken between April 1, 1890 and May 12, 1905, shows a variation of about 1.6 magn. Estimates from these plates gave the approximate limiting magnitudes, 8.6 to 10.2.
- 12 0.0. 120012 = H.V. 2998. An examination of this star on fourteen chart plates, taken between April 25, 1891 and May 9, 1905, shows a variation of about 4.0 magn. Estimates from these plates gave the approximate limiting magnitudes, 8.5 to 12.5.
- 12 17.4. 121774 = H.V. 2999. This star is A.G.C. 16865. An examination of sixteen chart plates of this object, taken between May 2, 1893 and March 29, 1905, shows a variation of about 1.8 magn. Estimates from these plates gave the approximate limiting magnitudes, 8.8 to 10.6.
- 12 32.3. 123216 = H.V. 3000. An examination of this star on twenty chart plates, taken between April 1, 1890 and May 12, 1905, shows a variation of about 1.7 magn. Estimates from these plates gave the approximate limiting magnitudes, 8.8 to 10.5.
- 13 15.5. 131563 = H.V. 3001. The spectrum of this star is already known as Type IV. An examination of eighteen chart plates of this object, taken between May 24, 1889 and January 30, 1901, shows a variation of about 1.5 magn. Estimates from these plates gave the approximate limiting magnitudes, 9.0 to 10.5.
- 13 36.4. On Plate B 5271, taken on May 25, 1890, the hydrogen lines are very faint and narrow in the spectrum of this star. On Plate B 36285, taken on June 24, 1905, the lines H β and H γ are bright on the edge of greater wavelength, while H δ , H ϵ , and H ζ appear as broad dark bands with narrow bright lines superposed towards the edge of shorter wave length. These give the spectrum on this plate the appearance of being that of a spectroscopic binary.
- 14 30.9. On Plate B 36127, taken on May 27, 1905, H β appears as a faint bright line.
- 15 37.8. 153738 = H.V. 3002. An examination of this
- h. m.*
 star on twenty-eight chart plates, taken between June 2, 1892 and February 11, 1907, shows a variation of about 1.3 magn. Estimates from these plates gave the approximate limiting magnitudes, 7.0 to 8.3.
- 17 35.4. 173557 = H.V. 3003. Variability suspected by Espin. A. N. 145, 327. An examination of this star on twenty-one chart plates, taken between August 17, 1892 and October 10, 1902, shows a variation of about 1.7 magn. Estimates from these plates gave the approximate limiting magnitudes, 8.0 to 9.7.
- 18 37.1. This spectrum is of the same type as C.D.M. — 47° 6614, described in H.C. 76.
- 20 7.1. Galactic longitude, 20° 45'. Galactic latitude, —13° 6'. In Heis' Atlas, Plate VII, in Aquila, in Plate XII, near border of Delphinus.
- 20 25.9. 202574 = H.V. 3004. An examination of this star on nine chart plates, taken between October 18, 1894 and October 28, 1903, shows a variation of about 2.2 magn. Estimates from these plates gave the approximate limiting magnitudes, 8.3 to 10.5.
- 20 27.6. 202732 = H.V. 3005. An examination of this star on ten chart plates, taken between August 4, 1890 and November 9, 1905, shows a variation of about 1.0 magn. Estimates from these plates gave the approximate limiting magnitudes, 8.5 to 9.5.
- 22 1.4. 220134 = H.V. 3006. An examination of this star on twenty chart plates, taken between December 22, 1890 and September 27, 1905, shows a variation of about 1.0 magn. Estimates from these plates gave the approximate limiting magnitudes, 8.2 to 9.2. This object was found to be variable by Mrs. Fleming on November 26, 1904, but since the change was slight, about half a magnitude, on the plates examined, publication was withheld until the star was rediscovered independently by Miss Leavitt in her examination of the Harvard Maps of the Sky. She found a change of about 0.7 magn.
- 23 6.3. This star is announced as of Type IV in Astronomy and Astrophysics, 12, 546. On Plate A 8155, taken with the 24-inch Bruce Telescope, on October 11, 1906, a good image of the spectrum of this star shows that it is of the same type as C. D.M. — 47° 6614, described in H. C. 76.

than H β . On Plate I 34569, taken on March 7, 1907, the line H β appears as a faint bright line, while the continuous spectrum is well shown and is similar to that on Plate I 33878. The object is difficult to describe on these plates, since all were taken with the 8-inch Draper Telescope using a small prism, and the portion visible on the individual plates amounts to 1.8, 0.1, 0.7, 1.6, and 1.8 millimetres, respectively. Plate I 10978, taken with the same telescope, using an 8° prism, shows a very faint spectrum which is similar to that on Plates I 33878 and I 34569.

EDWARD C. PICKERING.

OCTOBER 15, 1907.

HARVARD COLLEGE OBSERVATORY.

CIRCULAR 133.

15 NEW VARIABLE STARS IN HARVARD MAPS, Nos. 15, 18, AND 27.

THE systematic search for bright variable stars, by the method described in Circular 127, has already led to the announcement, in Circulars 127, 129, and 130, of nearly 100 new variables, and has furnished much material for the discussion of the distribution of such objects. Three additional regions, each 30° square, have been examined this autumn, by Miss Leavitt, and a summary of the results is given in Table 1, in the same form as Table I of Circular 130. The successive columns give the number of the plate, in the Map of the Sky, the right ascension and declination of its centre, the number of new variables discovered, the total number found in the examination, including those previously known, the proportion of new variables, the whole number known to exist at the end of the examination, the probable total, the proportion of the probable total found, the probable number unknown, and the proportion probably unknown. A description of the method of obtaining these quantities in the different columns is given in Circulars 127 and 130.

TABLE 1.
NUMBER AND DISTRIBUTION OF THE VARIABLES.

No.	Region.		New Variables.	Total Found.	Proportion New.	All.	Probable Number.	Proportion Found.	Probable No. Unknown.	Proportion Unknown.
15	10	$+30^\circ$	5	9	.56	10	11	.82	1	.09
18	16	$+30^\circ$	6	14	.43	22	28	.50	6	.21
27	10	0	4	7	.57	11	16	.44	5	.31

The following known variables were rediscovered during the examination:—In Region 15, W Cancri, R Leonis Minoris, S Leonis Minoris, and V Leonis; in Region 18, S Coronae Borealis, R Coronae Borealis, X Coronae Borealis, R Serpentis, 155229, RU Herculis, W Coronae Borealis, and g Herculis; in Region 27, R Sextantis, R Leonis, and 094501. The asteroid, Hebe, was also found, near opposition, on Plate AM 4046, taken January 25, 1906, exposure 60^m .

Before Harvard numbers could be assigned to the new variables, it was necessary to correct an error in Circular 130, Table II. The variables to which the Harvard numbers 2973 and 2974 were there assigned were already known as XZ Cygni and 200949, while 221955, to which the Harvard number 2982 was given, has been announced as suspected by Müller and Kempf in Potsdam Publications, 14, 429, and 17, 293, and as variable by Backhouse in West Hendon House Publications, III, 113. The Harvard numbers given to these three stars are here withdrawn, and are assigned, instead, to the first three of the new variables, given in Table II.

The discovery of variable 190965, H 2971, should be credited to Mrs. Fleming, as she had marked it on two spectrum plates previously to the publication of Circular 130. These plates are I 33685, taken November 23, 1905, and I 34173, taken August 15, 1906, and in each case the record was "Mc 5 d. var.?" Later, the variability was confirmed on chart plates by Miss Wells. In Table II, the designation is followed by the Harvard number, constellation, number in the Bonn Durchmusterung, right ascension and declination for 1900, brightest and faintest magnitudes observed, and observed range. The variables 090007, 093126, and 094233 appear to be of the Algol-type.

TABLE II.
NEW VARIABLES.

Designation.	Harvard No.	Constellation.	DM.	R. A. 1900.			Dec. 1900.		Bright.	Faint.	Range.
				<i>h.</i>	<i>m.</i>	<i>s.</i>	<i>°</i>	<i>'</i>			
090007	2973	Hydra	- 7° 2715	9	0	48	- 7	51.5	9.0	11.5	2.5
091906	2974	Hydra	..	9	19	53	- 6	21.8	10.0	<11.5	>1.5
093126	2982	Leo	+ 26° 1981	9	31	5	+ 26	41.4	9.0	10.6	1.6
094233	3007	Leo Minor	..	9	42	33	+ 33	45.2	9.5	11.5	2.0
094627	3008	Leo	+ 27° 1818	9	46	25	+ 27	22.3	9.8	10.4	0.6
094802	3009	Sextans	+ 2° 2264	9	48	16	+ 2	31.6	8.9	9.6	0.7
100039	3010	Leo Minor	..	10	0	7	+ 39	51.1	11.0	11.8	0.8
100224	3011	Leo	+ 24° 2183	10	2	8	+ 24	28.9	9.0	9.8	0.8
100709	3012	Hydra	- 9° 3017	10	7	24	- 9	49.5	9.1	9.8	0.7
152636	3013	Bootes	..	15	26	47	+ 36	8.1	10.2	11.0	0.8
155436	3014	Cor. Borealis	+ 36° 2672	15	54	47	+ 36	17.9	9.6	10.6	1.0
160325	3015	Hercules	+ 25° 3031	16	3	14	+ 25	10.3	8.8	9.7	0.9
163238	3016	Hercules	+ 38° 2803	16	32	28	+ 38	10.1	8.4	9.7	1.3
164917	3017	Hercules	+ 17° 3117	16	49	54	+ 17	0.0	10.0	10.8	0.8
165722	3018	Hercules	+ 22° 3048	16	57	15	+ 22	36.7	10.0	<11.0	>1.0

EDWARD C. PICKERING.

OCTOBER 16, 1907.

HARVARD COLLEGE OBSERVATORY.

CIRCULAR 134.

16 NEW VARIABLE STARS IN HARVARD MAP, NOS. 37 AND 46.

In continuation of the search for new variable stars, already described in H. C. 127, 129, 130, and 133, H. M. 37 and 46 have been examined by Miss Cannon. Nine new variable stars were found in H. M. 37, whose centre is in R. A. $6^h 00^m$, Dec. -30° . At the beginning of this investigation, 9 variable stars were known to exist in this region, of which T Leporis, T Pictoris, T Columbae, S Columbae, R Columbae, and 061133 were found. It, therefore, follows that there are probably, in this region, about 22 variable stars brighter than magnitude 10.5 at maximum, of which 18, or 0.82, have been discovered.

H. M. 46 has its centre in R. A. $0^h 00^m$, Dec. -60° . In the southern part of this region is situated the Small Magellanic Cloud in which 992 variable stars have been found by Miss Leavitt. The only one of these stars which is bright enough at maximum to appear on the plates taken with the Cooke lens, used in the present investigation, is probably H. V. 833, in R. A. $0^h 49^m.3$, Dec. $-70^\circ 25'$, (1900), announced in H. C. 79. This variable was rediscovered, and one new variable was found in the Cloud. In the region covered by H. M. 46, there are 11 known variables which are probably bright enough at maximum to appear on the plates examined in this research. 6 of these, S Tucanae, 004970, U Tucanae, T Tucanae, R Phoenicis, and S Phoenicis were found, besides 7 new ones. Therefore, the probable number of variable stars in this region is 24, of which 18, or 0.75, have been discovered.

A list of the new variables is given in Table I in which the successive columns give the designation, the Harvard number, the constellation, the number in either the Cordoba Durchmusterung or the Cape Photographic Durchmusterung, the right ascension for 1900, the declination for 1900, the brightest observed photographic magnitude, the faintest observed photographic magnitude, the range, and the class to which the variable belongs. Additional facts are given in the remarks following the table.

TABLE 1.
NEW VARIABLE STARS.

Desig.	H. V.	Constellation.	DM.	R. A. 1900.	Dec. 1900.	Bright.	Faint.	Range.	Class.
				<i>h. m. s.</i>	<i>° ' "</i>				
001060	3019	Tucana	..	0 10 17	-60 46.8	9.4	10.2	0.8	IV
003050	3020	Phoenix	-50° 118	0 30 19	-50 45.2	9.5	<11	>1.5	II
004872	3021	Tucana	-72° 69	0 48 10	-72 32.6	8.8	10.3	1.5	V
005463	3022	Tucana	..	0 54 9	-63 55.9	9.0	10.1	1.1	IV
045333	3023	Caelum	-33° 2018	4 53 12	-33 18.4	9.7	10.5	0.8	IV
060630	3024	Columba	-30° 2883	6 6 25	-30 43.2	10.4	<15	>4.6	II
061426	3025	Canis Major	-26° 2912	6 14 49	-26 7.9	9.8	<12	>2.2	II
062440	3026	Columba	..	6 24 35	-40 2.2	9.3	<11.5	>2.2	II
062935	3027	Columba	-35° 2972	6 29 44	-35 14.0	9.8	10.4	0.6	V
063942	3028	Puppis	-42° 2682	6 39 21	-42 16.6	9.1	<11.5	>2.4	II
063931	3029	Canis Major	..	6 39 44	-31 41.2	10.0	<12	>2.0	II
065223	3030	Canis Major	-23° 4628	6 52 36	-23 50.4	8.9	10.1	1.2	..
070025	3031	Canis Major	-25° 3986	7 0 3	-25 38.9	9.5	10.2	0.7	..
212770	3032	Indus	-70° 2860	21 27 41	-70 46.6	9.0	10.0	1.0	IV
232746	3033	Phoenix	-46° 14688	23 27 1	-46 32.2	8.5	<12	>3.5	II
235152	3034	Phoenix	-52° 12232	23 51 53	-52 46.9	10.1	11.0	0.9	...

REMARKS.

001060. This is the south following component of a double star. Variability was confirmed by an examination of 10 photographs, taken between July 18, 1899 and September 11, 1906. The period is short.

003050. This star is C. P. D. -50° 68, of which a note states "Only on check plate, not on measuring plate." Observations of 39 photographs, taken between November 15, 1897 and November 9, 1906, show that this is a variable star of long period. Approximate dates of maxima represented by these observations are J. D. 2414924 +230*d*. E

004872. This star is situated in the Small Magellanic Cloud. Observations have been made on 41 photographs, taken between July 13, 1896 and November 9, 1906. On 35 of these, the star is of normal brightness, on 5 it is decidedly fainter than normal. The variation appears certainly to be of the Algol type. On June 30, 1904, the star was faint, and about magnitude 10.3. On July 1, 5, and 30, 1904, it was of normal brightness, about 8.8. It was also faint on September 6 and 19, 1905, but on September 8, 1905, the light was normal. It was faint on August 6, 1906.

005463. This star has been observed on 18 photographs, taken between July 31, 1895, and May 18, 1903. On September 4, 1900, the magnitude was 10.2, on September 5, 1900, it was 9.0. On September 20,

1902, the magnitude was 9.0, and on September 25, 1902, the magnitude was estimated as 8.9. The period is therefore short.

045333. This star has been observed on 10 photographs, taken between November 13, 1900 and January 1, 1905. To gain some idea of the period, a series of photographs, taken between September 17, 1904, and January 8, 1905, was examined. The variable was at maximum on September 20, and also on November 21, 1904, and at minimum or fainter than normal on September 17, September 20, December 9, 1904, and January 8, 1905. The period is therefore short.

060630. Observations of this star have been made on 45 photographs, taken between November 16, 1896, and February 6, 1907. A plate taken with the Bruce Telescope, on April 1, 1900, shows no trace of this object, although stars as faint as magnitude 15 are seen. The observations are fairly well represented by the formula for times of maximum, J. D. 2414980 +300*d* E.

061426. This star is not contained in the C. P. D. Observations of 46 photographs, taken between September 16, 1895 and February 6, 1907, prove that it is a variable star of long period. Approximate elements for times of maximum are represented by the formula, J. D. 2414981 +127*d* E.

062440. This star has been observed on 28 photographs,

- taken between December 14, 1898 and November 9, 1906. The times of maximum are represented by the formula, J. D. 2415411 + 327^d E.
062935. This star was observed on 84 photographs, on 80 of which the magnitude is about 9.8, and on 4 of which, the light is fainter than normal brightness. The variability appears to be of the Algol type. The light was below normal on December 18, 1897, November 11, 1898, March 20, 1901 and November 17, 1903.
063942. This star has been observed on 24 photographs, taken between November 20, 1894 and November 9, 1906. The times of maximum are approximately represented by the formula, J. D. 2413153 + 180^d E.
063931. Observations of this star on 31 photographs, taken between October 7, 1895 and November 9, 1906, give the approximate elements, J. D. 2414753 + 230^d E.
065223. Estimates of the brightness of this star were made on 41 photographs, taken between November 28, 1896 and February 6, 1907. At minimum the photographic magnitude is not much brighter than that of the adjacent star, —23° 4627, which precedes 4^h.3 and is south 1^h.1. At maximum the variable is more than a magnitude brighter than the adjacent star.
070025. Estimates of the brightness of this star were made on 45 photographs, taken between November 13, 1894 and February 6, 1907. The period is not indicated and is probably irregular.
212770. This star has been observed on 17 photographs, taken between July 18, 1899 and May 22, 1906. The period is short.
232746. This star is given as magnitude 9.9 in the Cordoba Durchmusterung, but does not occur in the Argentine General Catalogue, the Zone Catalogue, or the Cape Photographic Durchmusterung. Observations of 32 photographs, taken between July 18, 1899 and November, 9, 1906, show that it is a variable star of long period, having a large range. These observations are represented by the formula for times of maximum, J. D. 2414860 + 251^d E.
235152. The variability was confirmed by an examination of 10 photographs, taken between August 20, 1889 and September 11, 1906. A regular period is not indicated in this examination.

The star 061133, —Columbae, which is C.P.D. —33° 1059 and C.D.M. —33° 2825, was announced in 1889 by Kapteyn as probably variable, because a Cape photograph taken on March 18, 1889, showed the star to be of magnitude 10.0, while 5 other photographs showed it as about magnitude 9.2. This object was inserted in the Second Catalogue of Variable Stars, H. A., 55, Part I, on the evidence of the Cape photograph and eleven Harvard photographs, on one of which it was fainter than on the others. See H. A. 55, 38. It was found independently in the present research, and was suspected to be of the Algol type before the object was known to be identical with 061133, already announced as a variable. 166 photographs were accordingly examined, on 13 of which the star is fainter than normal. The photographic range appears to be from magnitude 9.4 to 10.2, and the period to be approximately 2^d.8. A list of the plates on which the star appears to be certainly fainter than its normal magnitude, 9.4, is given in Table II, in which the successive columns give the plate number, the date, the Julian Day and decimal following Greenwich Mean Noon, and the magnitude.

The variability of SX Andromedae, H. V. 2905, was announced in Circular 129. Observations, by Miss Cannon, with the 6-inch Equatorial Telescope, give the following results. On March 6, 1907, the star was very faint, about magnitude 13. On April 7, 1907, it was invisible and fainter than

TABLE II.

MINIMA OF 061133.

Plate.	Date.			J. D.	Magn.	Plate.	Date.			J. D.	Magn.
	y.	m.	d.				y.	m.	d.		
B 4627	89	11	13	11320.826	9.9	M 1068	01	9	20	15648.865	10.0
B 7130	91	11	27	12064.825	10.1	B 31100	02	11	19	16073.722	9.8
B 12461	94	11	9	13142.782	10.2	B 31103	"	"	19	16073.754	10.2
B 20991	98	3	2	14351.600	10.0	M 2294	03	9	29	16387.808	19.1
B 24053	99	9	1	14899.901	10.1	M 2448	04	1	13	16493.693	9.9
B 26424	00	10	11	15304.896	10.1	M 3182	04	11	2	16787.810	10.1

magnitude 12.5. On October 15, November 1, November 9, and November 30, 1907, the magnitudes were 9.2, 9.1, 9.2, and 10.0, respectively. The variability, therefore, has been confirmed visually, and the observations are in accord with the elements published in Circular 129, which give October 29, 1907 as a computed date of maximum.

The variability of SZ Aquilae, H. V. 2917, and TT Aquilae, H. V. 2918, announced in Circular 129, has been confirmed visually by means of observations on August 6, 10, 12, 13, 15, and 28, 1907. SZ Aquilae was bright on August 6, and near minimum on August 12, 13, and 15. According to the formula given in Circular 129, maxima of this star occurred on August 2.9 and August 20.1, 1907. The light probably changes slowly near the time of maximum. TT Aquilae is especially interesting on account of its brightness and probable color changes. This star was observed to be increasing in light, from August 6 to August 12, 1907, and was at maximum on August 12, and August 13, 1907. According to the formula given in Circular 129, a maximum of TT Aquilae occurred on August 12.1, 1907.

EDWARD C. PICKERING.

DECEMBER 6, 1907.

HARVARD COLLEGE OBSERVATORY.

CIRCULAR 135.

25 NEW VARIABLE STARS IN HARVARD MAP, Nos. 24, 36, AND 42.

THE examination of photographs forming the Map of the Sky has been continued by Miss Leavitt, with the results described below. According to the plan adopted for this research, five photographs were superposed for each region, but the new variables thus discovered were, as usual, confirmed on a much larger number of plates. A summary of the results is given in Table I, in the same form as that employed in H. C. 130 and 133. The number of variables found during the examination, and given in the third and fourth columns, includes two in H. M. 36, and three in H. M. 42, which are either fainter at maximum than the magnitude 10.5, or are more than 15° from the centre of the plates. These five variables have been omitted from the totals and estimates given in the sixth, seventh, eighth, ninth, and last columns, in order to make the results comparable with those given in H. C. 127, 130, and 133.

TABLE I.

NUMBER AND DISTRIBUTION OF THE VARIABLES.

No.	Region.	New Variables.	Total Found.	Proportion New.	All.	Probable Number.	Proportion Found.	Probable No. Unknown.	Proportion Unknown.
24	$h. \quad ^{\circ}$ 4 0	7	11	.64	18	30	.37	12	.40
36	4 -30	9	14	.64	16	24	.50	8	.33
42	16 -30	9	22	.41	40	55	.35	15	.21

The following known variables were rediscovered during this examination :— In H. M. 24, U Arietis, *034601*, R Tauri, and W Orionis; in H. M. 36, T Fornacis, T Eridani, R Caeli, T Leporis, and T Columbae; in H. M. 42, S Librae, RS Librae, R Lupi, RR Librae, U Lupi, RZ Scorpii, Z Scorpii, *161726*, *162131*, ST Scorpii, RR Ophiuchi, RS Scorpii, and RR Scorpii. The variable *161726*, in

the above list, is H. V. 1114 in the cluster, N. G. C. 6121, announced in H. C. 90. The asteroids Ceres and Nysa were also found, in each case near opposition.

The new variables are given in Table II, in the same form as Table II of H. C. 133. The numbers given in the fifth column are those of the Bonn Durchmusterung or the Cape Photographic Durchmusterung, according

TABLE II.
NEW VARIABLES.

Desig.	H. V.	Constellation.	DM.	R. A. 1900.			Dec. 1900.		Bright.	Faint.	Range.
				<i>h.</i>	<i>m.</i>	<i>s.</i>	<i>°</i>	<i>'</i>			
024738	3035	Fornax	-38° 233	2	47	12	-38	29.5	9.3	10.0	0.7
030310	3036	Aries	+ 9° 398	3	3	6	+10	3.6	8.8	9.5	0.7
031901	3037	Taurus	- 1° 484	3	19	15	- 1	5.2	9.9	10.8	0.9
032825	3038	Eridanus	-26° 388	3	28	10	-25	59.8	8.4	9.1	0.7
032916	3039	Eridanus	..	3	29	36	-16	29.7	9.6	<11.0	>1.4
034946	3040	Horologium	..	3	49	46	-46	7.0	8.5	<11.0	>2.5
035015	3041	Eridanus	-15° 686	3	50	7	-15	13.8	9.0	9.8	0.8
035417	3042	Eridanus	-17° 766	3	54	26	-17	31.1	10.0	10.9	0.9
040107	3043	Eridanus	- 8° 788	4	1	59	- 7	56.4	9.6	10.6	1.0
041318	3044	Eridanus	..	4	13	29	-18	45.2	8.9	13.0	4.1
041705	3045	Eridanus	- 5° 892	4	17	39	- 5	44.5	8.8	9.8	1.0
041903	3046	Taurus	+ 3° 601	4	19	15	+ 3	53.5	8.5	9.5	1.0
043227	3047	Eridanus	-27° 581	4	32	32	-27	46.9	9.7	10.5	0.8
044515	3048	Eridanus	-15° 872	4	45	13	-15	54.3	8.8	9.6	0.8
045903	3049	Eridanus	- 4° 1029	4	59	31	- 3	56.0	9.5	<10.5	>1.0
050534	3050	Columba	-34° 595	5	5	10	-34	38.7	8.8	9.7	0.9
151528	3051	Scorpius	..	15	15	36	-28	19.2	10.9	11.5	0.6
152726	3052	Scorpius	..	15	27	21	-26	50.8	10.2	<11.5	>1.3
155746	3053	Norma	-45° 7780	15	57	48	-46	1.1	8.6	10.0	1.4
155834	3054	Lupus	..	15	58	37	-34	6.2	10.0	<11.5	>1.5
160732	3055	Scorpius	..	16	7	7	-32	5.2	10.5	11.4	0.9
164132	3056	Scorpius	-32° 4244	16	41	44	-32	46.0	10.3	<11.5	>1.2
164836	3057	Scorpius	-36° 7072	16	48	2	-36	43.4	8.7	10.0	1.3
165125	3058	Scorpius	-25° 5896	16	51	15	-25	38.5	10.2	<11.6	>1.4
170432	3059	Scorpius	-32° 4382	17	4	47	-32	12.1	9.6	11.3	1.7

REMARKS.

034946. A star of magnitude 11 follows the variable about 9°.	044515. A star of magnitude 11 precedes the variable about 6°.
041318. A star of magnitude 13 is south of the variable about 1'.5.	151528. This star is C. DM. - 28° 11301.
	160732. A star of magnitude 11.5 is north of the variable about 0'.5.

as the corresponding variables are north or south of declination -23° . The large number of variables of the Algol type found in this research has been remarkable from the beginning. In Table II, eight, or nearly one-third, are probably of this class or of that of β Lyrae, which is frequently difficult to distinguish from it. Their designations are as follows:— 024738, 035015, 035417, 041705, 155746, 164132, 164836, and 165125. The light of 155746 and 164836 does not appear to be quite constant when near maximum. The periods of 034946, 050534, 152726, and 170432, are probably long. Among the variables whose periods are probably short, are 041903, and 044515. All of the new variables have been confirmed on from 10 to 40 plates.

The total number of stars examined is estimated as 18,700 in H. M. 24, 22,700 in H. M. 36, and 25,100 in H. M. 42. The number of known variables, therefore, is about one in 1000 in H. M. 24, one in 1400 in H. M. 36, and one in 600 in H. M. 42. The probable numbers are about one in 600, one in 950, and one in 450, for the three regions, respectively. It appears, therefore, that the large number of variables in H. M. 42 is really significant, and should be considered in any general discussion of the region. A large part of the constellation Scorpius is included, as well as the nebulous region in Ophiuchus. The region was found to be very rich, also, in fainter variables, of which 72 were announced in H. C. 90, besides 33 in the cluster N. G. C. 6121.

EDWARD C. PICKERING.

DECEMBER 17, 1907.

HARVARD COLLEGE OBSERVATORY.

CIRCULAR 136.

COMPARISON STARS FOR U GEMINORUM.

THE variable stars, U Geminorum, SS Cygni, and probably 31,1907, form a class by themselves. Not only the light curves, but the spectra, are unlike those of other variables. Their periods are irregular, or more strictly not uniform, and in general equal from fifty to one hundred days; they are thus intermediate between those of long and short period variables. These stars are very faint, for a large part of the time, increasing unexpectedly and so suddenly by three or four magnitudes that it is difficult to study this portion of their light curves. The spectra are nearly continuous, although the hydrogen lines are faintly visible and are perhaps bright on the edge of greater wave length. They differ strikingly from the normal banded spectra of variable stars of long period, in which the hydrogen lines are bright.

The variability of U Geminorum was discovered in 1855 by Hind. It has, however, been observed much less frequently than SS Cygni, probably because during a large part of the time it is so faint as to be beyond the reach of the telescopes commonly used by observers of variable stars. A sequence of comparison stars was selected by Winnecke, which is given in Table I, together with those employed by other observers. It is unfortunate that in this, as in other cases, later observers have not adopted the same comparison stars as their predecessors. They might at least have included them, adding others, if they wished. It would then be much easier to reduce all to a uniform system of magnitudes. The designation, the right ascension of each comparison star minus that of the variable, the difference in declination, and the photometric magnitude are given in the first four columns of Table I. The photometric magnitudes were obtained from a series of measures by the writer, with the 12-inch Meridian Photometer. Each star was generally observed on three nights, two sets of four settings each being made on each night. The next twelve columns give the designations and estimated brightness employed by Winnecke, Schönfeld, Pogson, Baxendell, Knott, and Hagen. The brightness was expressed in magnitudes by

Winnecke, Pogson, Baxendell, and Knott, and in grades by Schönfeld, and Hagen. The results for Winnecke are taken from the *Astron. Nach.* 47, 246; for Schönfeld, from *Veroff. de Grossherz. Sternwarte zu Heidelberg*, 1, 266; those of Pogson, Baxendell, and Knott, from *M. N.* 67, 119, 316, and 330, and those of Hagen from his *Atlas Stellarum Variabilium*. The following column gives the mean brightness in grades from estimates on three evenings, by Mr. Campbell. Each of the estimates of brightness has been reduced graphically to the scale of the photometric measures given in the fourth column. The mean of all the magnitudes, and the residuals from the mean, are given in the last two columns of the table. Thus, the first star had the photometric magnitude 8.49. It was not used as a comparison star by Winnecke or Baxendell. Its brightness according to the estimate of Schönfeld was 8.50, according to that of Pogson 8.54, of Knott 8.44, of Hagen 8.50, and of Campbell 8.46. The mean

TABLE.
COMPARISON STARS FOR U GEMINORUM.

Des.	$\Delta\alpha$	$\Delta\delta$	Ptm.	Winnecke.		Schönfeld.		Pogson.		Baxendell.		Knott.		Hagen.		Camp.	Adopt. Magn.	Ph	W	S	Po	B	K	Hg	Ca
a	+ 4	-19.8	8.49	..	..	p	41.0	a	8.8	..	..	a	8.6	1	0	0	8.49	00	..	01	05	..	05	01	03
b	+ 86	- 6.9	8.98	o	9.2	o	36.5	b	9.2	..	..	c	9.2	3	6	4	9.01	03	13	01	03	..	15	03	27
c	+133	-17.7	9.16	n	9.4	n	35.1	..	..	..	..	..	..	2	5	9	9.14	02	24	02	..	..	..	24	04
d	+ 79	- 9.6	9.36	m	9.3	m	35.9	e	9.4	..	..	b	9.3	4	10	12	9.29	07	03	13	03	..	02	01	07
e	- 41	+34.8	9.28	..	..	q	31.9	..	..	..	..	..	..	5	14	16	9.51	23	..	04	..	..	..	07	21
f	+244	- 5.1	9.96	..	..	k	25.7	..	..	..	..	..	..	..	..	..	10.06	10	..	11	..	..	..	..	..
g	- 45	+35.7	10.11	..	..	r	27.2	..	..	..	..	..	..	8	23	21	10.10	01	..	11	..	..	..	02	10
h	-106	+14.3	10.19	i	..	..	..	..	..	..	..	..	..	..	..	..	10.19	A	..	..	..	..	..	..	..
k	+124	- 4.4	..	k	10	..	..	..	..	..	..	..	..	..	..	..	10.23	..	A	..	..	..	..	..	..
l	- 46	+16.7	..	..	..	..	..	n	10.2	..	..	..	..	11	26	..	10.28	..	..	..	01	..	..	00	..
m	+262	-12.9	10.30	l	10	l	24.3	..	..	..	..	..	..	..	..	..	10.29	01	06	06	..	..	..	..	..
n	- 70	+14.5	..	..	..	i	..	d	10.3	..	..	d	10.3	9	26	..	10.37	..	..	..	06	..	04	10	..
o	+273	-11.7	10.80	h	10	h	20.8	..	..	..	..	..	..	..	..	..	10.86	06	R	06	..	..	..	..	..
p	- 27	- 9.9	10.89	..	..	..	..	e	10.8	..	..	e	10.6	16	38	26	10.92	03	..	..	13	..	10	08	12
q	+ 2	+ 5.4	11.54	f	10.9	f	18.7	f	11.3	f	..	f	11.2	18	45	30	11.43	11	19	14	13	..	03	13	13
r	+ 7	- 3.8	11.71	g	10.7	g	16.6	m	11.3	k	..	..	R	23	57	34	11.68	03	38	06	12	..	..	28	10
s	+ 18	- 0.1	12.02	d	11.4	d	15.2	g	11.9	g	11.05	g	12.3	25	66	41	12.29	27	10	25	07	03	11	09	31
t	+ 6	+ 4.4	12.60	e	11.3	e	12.4	h	12.3	h	11.10	h	12.3	24	63	39	12.42	18	17	06	21	10	02	17	02
u	- 45	- 2.7	..	..	..	c'	..	..	..	..	..	..	..	26	71	..	12.56	..	..	..	..	..	A	..	..
w	- 43	+ 2.3	13.20	c	11.7	e	..	..	..	..	..	..	..	31	86	44	13.01	19	21	..	..	..	..	11	08
x	+ 4	- 2.9	13.29	b	12.2	a'	2.0	l	13.0	w	12.05	k	13.3	33	92	49	13.31	02	11	01	02	05	04	00	02
y	- 2	+ 2.1	13.61	a'	12.6	..	..	k	13.7	l	12.45	l	13.7	39	103	56	13.70	09	18	..	..	06	10	07	12

of these magnitudes is 8.49, and the residuals, 0.00, +0.01, +0.05, -0.05, +0.01, and -0.03.

There are two stars near the variable, and south following it. They are called g and b by Winnecke, the second being the nearer and fainter. It is here assumed that the magnitudes of these stars were reversed by Pogson, and that Knott observed only the fainter, although he gives it in the position of the first, according to the identification by Turner. A faint star, z, 1'.0 south of U, is estimated by Mr. Campbell as 5 grades fainter than y, and therefore magn. 14.12. Winnecke's estimate of star o, 10, has been rejected for discordance, since it would give the residual 63.

The numbers of residuals in the last column, for the eight observers, are 17, 11, 14, 11, 4, 10, 16, and 14, respectively. Their average values are ± 0.09 , ± 0.16 , ± 0.08 , ± 0.08 , ± 0.06 , ± 0.07 , ± 0.09 , and ± 0.12 . These values do not differ more than might be expected if all the observations were equally good, except in the case of Winnecke, whose magnitudes were probably intended to be only approximate.

EDWARD C. PICKERING.

MARCH 30, 1908.

HARVARD COLLEGE OBSERVATORY.

CIRCULAR 137.

25 NEW VARIABLE STARS IN HARVARD MAP, Nos. 31 AND 43.

HARVARD Map No. 43, which has a centre in R. A. = $18^h 00^m$, Dec. = -30° , has been examined for variable stars, by Miss Cannon. 22 new variable stars were found, and 15 which were already known. The planets Mars and Uranus also appear on several plates. The known variables thus found are RS Scorpii, RR Scorpii, 170432, RX Scorpii, X Sagittarii, SV Scorpii, W Sagittarii, 180222a, 180829, Y Sagittarii, RV Sagittarii, X Scuti, U Coronae Australis, SU Sagittarii, and RY Sagittarii. At the beginning of this investigation, there were in the region of this map, 42 known variable stars as bright as magnitude 10.5 at maximum. If we therefore assume that the number of known variables found is to the total number found, as the number already known is to the whole number existing in the region, it follows that there are probably 104 variable stars in the region of H. M. 43, of which 64 or 0.62 have been discovered. In H. C. 129, 13 new variable stars were announced in H. M. 31, which has a centre in R. A. = $18^h 00^m$, Dec. = 0° . In examining some suspected objects in this region, three additional new variable stars were found, and are included in Table I. Apparently eleven of the new variable stars belong to Class V, Algol variables; ten to Class IV, short period variables; two to Class II, long period variables; one, a Nova, to Class I. All of the stars showing a variation of less than one magnitude were confirmed by other observers.

The successive columns of Table I give the designation of the variable, expressed in hours, minutes, and degrees, the number in the list of variables discovered at Harvard, the constellation, the number in the Durchmusterung, the right ascension for 1900, the declination for 1900, the brightest and faintest observed magnitudes, the range, and the Class.

TABLE 1.
NEW VARIABLE STARS.

Desig.	H. V.	Constellation.	DM.	R. A. 1900.			Dec. 1900.	Bright.	Faint.	Range.	Class.	
				<i>h.</i>	<i>m.</i>	<i>s.</i>	<i>°</i>	<i>'</i>				
174734a	3060	Scorpius	R	17	47	10	-34	22.6	8.7	<12	>3.3	II
174734b	3061	Scorpius	..	17	47	28	-34	19.7	8.8	..	..	I?
174916	3062	Hercules	+16° 3311	17	49	42	+16	57.1	8.2	9.3	1.1	V
174933	3063	Scorpius	-33° 12638	17	49	42	-33	48.0	9.5	11.0	1.5	IV
175237	3064	Corona Austr.	-37° 12045	17	52	28	-37	52.3	8.7	9.7	1.0	V?
175423	3065	Sagittarius	-23° 13773	17	54	55	-23	1.1	8.7	10.1	1.4	V
180240	3066	Corona Austr.	R	18	2	13	-40	13.1	10.1	10.9	0.8	IV?
180218	3067	Sagittarius	-18° 4799	18	2	34	-18	34.0	8.0	9.0	1.0	IV?
180423	3068	Sagittarius	-23° 14026	18	4	48	-23	42.2	9.5	10.2	0.7	V
180516	3069	Sagittarius	..	18	5	19	-16	29.1	9.8	11.3	1.5	V?
180529	3070	Sagittarius	-29° 14636	18	5	50	-29	52.9	9.5	10.7	1.2	V?
180623	3071	Sagittarius	-23° 14072	18	6	58	-23	8.5	7.2	8.2	1.0	IV?
181119	3072	Sagittarius	-19° 4945	18	11	7	-19	6.6	8.0	9.2	1.2	IV?
181113	3073	Serpens	..	18	11	40	-13	6.1	10.1	10.7	0.6	..
181625	3074	Sagittarius	-25° 13054	18	15	57	-25	17.1	8.9	11.2	2.3	V
181916	3075	Sagittarius	-16° 4859	18	18	57	-16	50.7	8.6	10.0	1.4	IV?
181912	3076	Scutum	-12° 5045	18	19	54	-12	45.2	8.6	9.3	0.7	IV?
182109	3077	Scutum	- 9° 4736	18	21	5	- 9	15.2	7.5	8.5	1.0	V
183342	3078	Corona Austr.	-42° 13498	18	33	37	-42	19.8	9.8	10.4	0.6	V?
183807	3079	Scutum	- 7° 4683	18	38	19	- 7	49.9	7.5	8.4	0.9	IV
183819	3080	Sagittarius	-19° 5148	18	38	43	-19	29.8	8.8	9.7	0.9	V?
184334	3081	Sagittarius	-34° 13135	18	43	3	-34	47.5	8.9	10.5	1.6	V?
184420	3082	Sagittarius	-20° 5283	18	44	47	-20	23.5	7.6	8.6	1.0	IV?
185323	3083	Sagittarius	-23° 14922	18	53	38	-23	50.2	8.8	9.9	1.1	IV
190129	3084	Sagittarius	R	19	1	16	-29	1.2	9.0	<13	>4'	II?

REMARKS.

174734a. This is the south preceding component of a double star, one or both of which might be identified as C. P. D. -34° 7303, magn. 9.2. The position of the variable precedes that of the catalogue star, 0'.7, south, 0'.3. When the variable is at maximum, the two objects are approximately equal in brightness. Observations of the variable on 111 photographs, taken between July 18, 1899 and May 2, 1907, show that the times of maxima may be represented by the formula $J. D. 2411360 + 237 E$.

174734b. On 193 photographs, taken between July 18, 1899, and September 1, 1907, a star of the eleventh magnitude appears nearly in the position of this object and shows no certain variability. 111 of these photographs were taken with the Bache Telescope, 80 with the Cooke lens, and 2 with the Bruce

Telescope. Plates taken with the Bache and Bruce Telescopes show this star to be double, the south preceding component being brighter than the north following. The position of the brighter component, for 1875, is R. A. = 17^h 45^m 48^s.0, Dec. = -34° 19'.2. The photographs on which the star was found to be brighter than the magnitude 11, are enumerated in Table II, and discussed below.

174916. This star has been observed on 40 photographs, taken between July 25, 1899 and May 25, 1905. It is of normal brightness on 37, and faint on 3, of these photographs. The variation is of the Algol type, and the minimum is apparently of very short duration. The spectrum of this star is first type, either Class B 9, or A.

174933. This star has been observed on 15 photographs,

- taken between May 1, 1893 and August 20, 1903. The period is probably short.
175237. This star is faint on 3 out of 15 photographs, taken between July 20, 1893 and August 25, 1907. The spectrum is Class A, and the variation may be of the Algol type.
175423. This star is faint on 8 out of 59 photographs, taken between July 26, 1899 and August 25, 1907. On the other 51 plates, the light is nearly normal. The variation is probably of the Algol type. The spectrum is Class A.
180240. This is C. P. D. -40° 8479, and is not in the Cordoba Durchmusterung. The period appears to be short, and the variation is suspected to be like that of variables in clusters.
180218. The variability was confirmed by an examination of 18 photographs, taken between September 6, 1901 and August 25, 1907. The period is probably short. The spectrum is Class G5.
180423. This star is faint on 3 out of 79 photographs, taken between July 23, 1889 and September 1, 1907. The variation appears to be of the Algol type. Variability was confirmed by Mrs. Fleming and Miss Wells.
180516. This star is faint on 7 out of 46 photographs, taken between July 21, 1893 and May 5, 1904. The variation may be of the Algol type.
180529. This star is faint on 6 out of 45 photographs, taken between August 2, 1900 and May 2, 1905. The variation may be of the Algol type.
180623. The period is probably short. The spectrum is Class G.
181119. The period is probably short.
181113. This star has been observed on 27 photographs, taken between May 30, 1891 and June 17, 1904. The variability was confirmed by Miss Wells.
181625. This star is fainter than normal on 15 out of 109 photographs, taken between August 21, 1889 and September 1, 1907. Three plates taken with the Cooke lens, having respectively, 17, 11, and 18 exposures of 30 minutes each, show the star to be varying, and that minima occurred on July 13, 1904, June 27, 1906, and July 12, 1907. The spectrum of this star is Class A. It has the largest range of variation of any star of the Algol type given in Table I.
181916. The period is probably short.
181912. This star was observed on 43 photographs, taken between June 22, 1901 and September 1, 1907. The period is probably short.
182109. This star is faint on 2 out of 35 photographs, taken between June 16, 1889 and July 1, 1904. The variation is probably of the Algol type. The spectrum is Class B3.
183342. This star is faint on 6 out of 96 photographs, taken between July 3, 1889 and August 6, 1906. The variation was confirmed by two other observers. The range is small, but easily seen, as suitable comparison stars are near.
183807. The period appears to be short. The spectrum is Class G.
183819. This star is faint on 5 out of 66 photographs, taken between May 29, 1891 and August 25, 1907. The variation may be of the Algol type.
184334. This star is faint on 3 out of 25 photographs, taken between May 29, 1891 and September 1, 1907. The variation may be of the Algol type.
184420. The period is probably short.
185323. The period is probably short.
190129. This is C. P. D. -29° 5883, magn. 10.2, and is not in the Cordoba Durchmusterung. The period is probably several months.

On 15 photographs, taken at Arequipa with the Cooke lens, between June 14, and September 11, 1906, the star 174734b shows large variations in brightness. No plates covering this region were taken with the Bruce or Bache Telescopes, during this interval. Observations of this star are given in Table II, in which the successive columns give the number of the Plate, the date, the length of exposure, the Julian Day, after subtracting 2,410,000, and the magnitude. It will be seen that on June 1, 1906, this object was not brighter than magnitude 11, but on June 14, 1906, the magnitude was 9.7. From June 14 to July 2, it increased to magnitude 8.9, and probably remained nearly constant until August 6. On August 9, it was distinctly fainter, and decreased

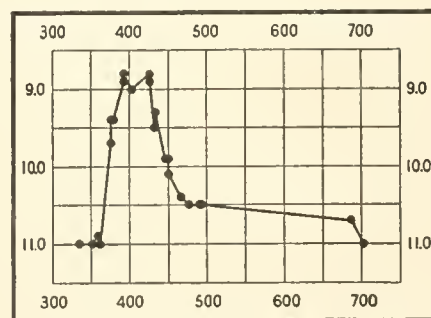


FIG. 1.

TABLE II.

OBSERVATIONS OF 174734b.

Plate.	Date.			Exp.	J. D.	Magn.	Plate.	Date.			Exp.	J. D.	Magn.
	y.	m.	d.	m.				y.	m.	d.	m.		
4205	1906	5	4	61	7335	11.0	4480	1906	8	9	65	7432	9.5
4249	"	5	22	65	7353	11.0	4486	"	8	10	64	7433	9.3
4269	"	5	29	63	7360	10.9	4527	"	8	24	69	7447	9.9
4273	"	6	1	62	7363	11.0	4539	"	8	27	61	7450	9.9
4311	"	6	14	65	7376	9.7	4540	"	8	27	102	7450	10.1
4321	"	6	15	64	7377	9.4	4562	"	9	11	60	7465	10.4
4331	"	6	16	60	7378	9.4	4590	"	9	22	50	7476	10.5
4365	"	7	2	60	7394	8.9	4612	"	10	9	62	7493	10.5
4367	"	7	2	60	7394	8.9	4613	"	10	9	75	7493	10.5
4369	"	7	2	61	7394	8.8	4620	"	10	11	85	7495	10.5
4388	"	7	11	60	7403	9.0	4778	1907	4	20	120	7686	10.7
4455	"	8	6	70	7429	8.8	4804	"	5	7	60	7703	11.0
4457	"	8	6	62	7429	8.9							

gradually until its magnitude was 10.5 on September 22. Since then, no star brighter than magnitude 10.5 to 11 has been seen in this position. These variations are represented graphically in Figure 1. Owing to the duplicity of the object the image when faint is ill-defined on photographs taken with the Cooke lens, and estimates are difficult and somewhat uncertain. So far as is now known, this object has had but one maximum, and should apparently be regarded as a Nova, whether or not we assume that it is identical with the star of the eleventh magnitude in approximately the same position. If identical, its light curve appears to be similar to that of T Coronae which was observed at Bonn, and recorded in the Durchmusterung before its sudden increase in light in 1866. This object is still visible in the sky as a star of about the tenth magnitude. RS Ophiuchi is another object of the same character. See H. C. 99. The star 174734b should therefore be designated as Nova Scorpil, No. 2, the name Nova Scorpil, No. 1, being applied to T Scorpil.

EDWARD C. PICKERING.

JUNE 26, 1908.

HARVARD COLLEGE OBSERVATORY.

CIRCULAR 138.

060547. THE VARIABLE STAR, 31, 1907.

WHEN the discovery of the variable star 31, 1907 was announced, A. N. 174, 363, it was evident that it was an object of unusual interest, since its maximum magnitude was given as 8.5, and its minimum as <14.5 . It was accordingly placed on the list of variable stars, more than three hundred in number, to be observed here at least once a month. Although looked for with the 24-inch Reflector, on October 10 and November 7, 1907, it was too faint to be visible. On receiving the announcement from Kiel, on March 7, 1908, contained in H. B. 324, that this object belongs to the same class as U Geminorum and SS Cygni, systematic observations were at once undertaken early and late on every clear night. It will be noticed that, in the cut published in the *Astron. Nach.*, 174, 363, this variable is nearly midway between the stars c and d. The position of this point for 1855, therefore, would be R. A. = $6^h 2^m 27^s.4$, Dec. = $+47^\circ 45'.2$, which does not agree with the position given for the variable by the discoverer, Dr. Silbernagel, R. A. = $6^h 2^m 12^s$, Dec. = $+47^\circ 47'.7$ (1855). The position according to the measures made here is R. A. = $6^h 2^m 24^s.2$, Dec. = $+47^\circ 45'.9$ (1855).

The vicinity of the variable is shown in Figure 1, which is enlarged to a scale of $20'' = 0.1$ cm., from a negative taken by the Rev. J. H. Metcalf, with his 12-inch Doublet on J. D. 2418033.547.

Table I contains the sequence of comparison stars which has been selected for this variable. The designation, the right ascension for 1900, and the declination for 1900, are given in the first three columns. The magnitude, as measured with the 12-inch Meridian Photometer, is given in the fourth column. The brightness, expressed in grades, was next derived from three independent estimates of the intervals, on different nights, by Mr. Campbell. These were reduced graphically to the photometric scale, and the mean of the photometric and visual magnitudes given in the fifth column has been adopted as the magnitude for visual observations. The difference found by subtracting the photometric

from the visual magnitude is given in the sixth column. The photographic magnitude, found by the method described in H. C. 112 and H. C. 125, is given in the seventh column. Stars fainter than u could not be measured in this way.

NORTH.

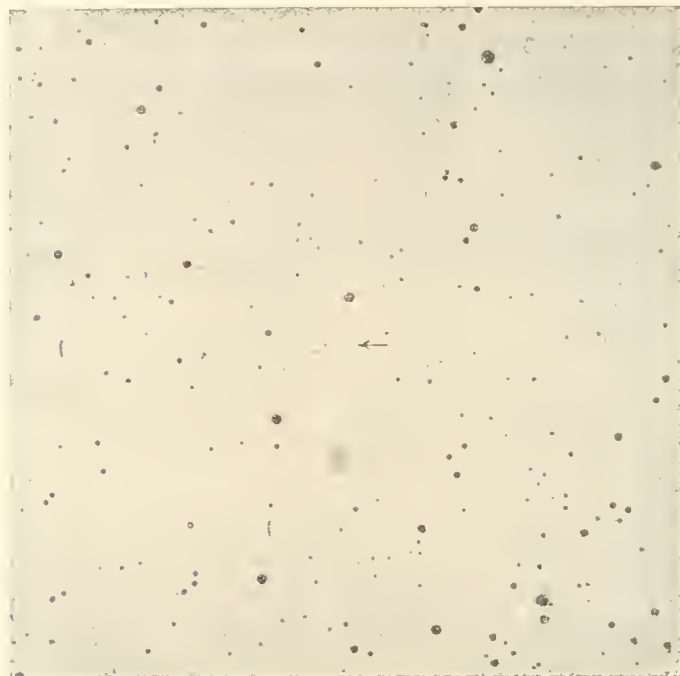


FIG. 1.

tude as the North Pole. A second exposure of the same length was then made on the Pole. The residuals found by subtracting the mean from the individual magnitudes are given in the tenth column, for Plates I 35206, I 35207, and I 35211. The average value of these residuals is only ± 0.07 , and the absence of systematic differences shows the excellence of the method employed. The principal objection to this method, so far found, is shown by the values in the eleventh column, which give the residuals corresponding to Plate I 35210. A marked systematic difference in scale is shown by this plate, although it was taken on the same night as I 35211 and under atmospheric conditions which appeared to be more favorable, as the record indicated that the sky was much freer from cloud. Probably the air was less steady in one part of the sky than in the other, and accordingly the bright stars would appear larger and brighter, and the faint stars larger and fainter, or nearly invisible. The only remedy for this condition, which would apparently be a rare one, is to take a number of

Accordingly, the intervals beginning with star r , were estimated independently on these plates. The resulting magnitudes were found graphically, and are inserted in the eighth column. The difference obtained by subtracting the visual from the photographic magnitude is given in the ninth column. A positive sign here indicates that the star is red. Four photographs were measured by Miss Leland, to determine the photographic brightness of the comparison stars. Each was taken with the 8-inch Draper Telescope, with an exposure of 10^m , at the time that the region had the same alti-

photographs, and if the scale of one differs from all the others, reject it. The class of spectrum of the brighter stars is given in the twelfth column. The spectrum of the variable appears to be nearly continuous, like that of U Geminorum, and SS Cygni. It certainly does not show the bright hydrogen lines characteristic of variables of long period.

TABLE I.
COMPARISON STARS.

Des.	R. A. 1900.			Dec. 1900.		Ptm.	Ad. Vis.	Diff.	Ptg.	Est.	V-P.	Residuals.	R.	Sp.
V	<i>h.</i> 6	<i>m.</i> 5	<i>s.</i> 48.6	° +47	' 45.7	..	..	..	..	..	..	..	..	..
a	6	3	24.0	+47	31.2	7.76	7.64	24	7.46	..	18	28 06 33	05	A
b	6	5	53.8	+47	18.7	7.79	7.98	39	8.39	..	41	07 01 06	24	K
c	6	8	6.0	+47	26.5	8.98	8.87	22	8.19	..	68	08 04 13	40	F
d	6	4	58.5	+47	34.3	9.44	9.44	00	9.54	..	10	14 04 18	27	G
e	6	6	8.4	+47	24.1	..	10.13	A	10.60	..	47	10 08 01	11	G
f	6	6	12.0	+47	35.2	10.50	10.52	04	10.55	..	03	10 03 11	02	F
g	6	6	8.2	+47	42.3	10.78	10.76	04	10.84	..	08	07 06 02	06	G
h	6	5	26.1	+47	33.0	10.62	10.77	30	10.84	..	07	07 06 02	14	F
k	6	5	48.9	+47	47.7	10.98	10.79	38	10.60	..	19	10 08 01	11	A
l	6	6	30.9	+47	49.2	10.87	11.02	29	11.58	..	56	09 05 03	12	K
m	6	5	30.2	+47	37.4	11.22	11.15	14	11.52	..	37	07 04 02	00	K
n	6	7	4.9	+47	49.8	11.45	11.40	09	11.73	..	33	07 02 08	23	..
o	6	5	21.0	+47	39.8	11.43	11.62	37	12.28	..	66	05 08 03	35	..
p	6	5	48.1	+47	32.1	11.80	11.80	00	12.08	..	28	05 10 04	30	..
q	6	6	9.3	+47	46.2	12.42	12.42	00	12.54	..	12	07 02 06	33	..
r	6	5	14.9	+47	48.1	..	12.64	..	12.75	12.76	12	09 09 00	35	..
s	6	5	18.3	+47	41.2	..	12.98	..	13.15	13.14	16	08 03 05	47	..
t	6	5	27.0	+47	44.1	..	13.26	..	13.68	13.64	40	05 04 02	58	..
u	6	5	35.7	+47	44.1	..	..	..	13.89	13.93	..	03 03 ..	64	..
w	6	5	39.0	+47	46.2	..	..	..	13.92	14.30	..	.. A ..	..	..
x	6	5	54.6	+47	45.7	..	..	..	..	15.08	..	..	..	..
y	6	5	58.1	+47	45.4	..	..	..	..	15.43	..	..	..	..
z	6	5	55.0	+47	45.3	..	..	..	..	15.78	..	..	..	..
<i>α</i>	6	5	46.5	+47	45.2	..	..	..	..	16.09	..	..	..	..
<i>β</i>	6	5	36.6	+47	45.1	..	..	..	..	16.37	..	..	..	..
<i>γ</i>	6	5	49.5	+47	45.4	..	..	..	..	16.8	..	..	..	..

A list of the stars within 2' of the variable in both coördinates has been prepared by Mrs. Fleming and is contained in Table II. The designation, right ascension for 1900, declination for 1900, and photographic magnitude are given in the successive columns.

TABLE II.
STARS WITHIN 2' OF THE VARIABLE.

Des.	R. A. 1900.			Dec. 1900.		Magn.	Des.	R. A. 1900.			Dec. 1900.		Magn.
	<i>h.</i>	<i>m.</i>	<i>s.</i>	<i>°</i>	<i>'</i>			<i>h.</i>	<i>m.</i>	<i>s.</i>	<i>°</i>	<i>'</i>	
β	6	5	36.6	+47	45.1	16.4	x	6	5	54.6	+47	45.7	15.1
α	"	"	46.5	"	45.2	16.1	z	"	"	55.0	"	45.3	15.8
V	"	"	48.6	"	45.7	"	4	"	"	55.5	"	44.0	16.8
γ	"	"	49.5	"	45.4	16.8	5	"	"	57.2	"	46.8	16.4
1	"	"	51.4	"	44.3	17.0	7	"	"	58.1	"	45.4	15.4
2	"	"	52.7	"	46.8	16.0	6	"	"	59.2	"	44.1	16.6
3	"	"	54.6	"	46.7	16.2							

Owing to the faintness of the variable at minimum, it was visible on only a small portion of the plates covering the region. A list of these is given in Table III. The year, omitting the two left hand figures, is given in the first column. The Julian Day and decimal, omitting the three left hand figures, 241, is given in the second column. It is followed in the third column by a letter

TABLE III.
VARIABLE SEEN.

Year.	J. D.	Inst.	Ex.	Magn.	Est.	Year.	J. D.	Inst.	Ex.	Magn.	Est.	Year.	J. D.	Inst.	Ex.	Magn.	Est.
91	1748.674	i	<i>m.</i> 14	12.13	12.0	02	5765.553	e	<i>m.</i> 61	10.48	10.3	08	8006.624	e	<i>m.</i> 64	12.23	11.9
92	2462.699	i	15	13.56	13.6	"	5767.646	i	10	10.17	10.6	"	8008.512	i	10	10.62	10.7
93	2767.864	i	12	10.74	10.7	03	6146.774	e	84	11.96	11.8	"	" .522	i	14	10.22	10.4
94	3113.908	a	11	13.84	13.5	"	6443.767	e	67	10.52	10.4	"	" 637	i	10	10.17	10.6
97	3994.597	i	13	14.02	14.2	"	6447.761	e	85	12.13	12.0	"	" 657	i	10	10.17	10.5
"	4012.663	i	31	14.12	13.7	04	6495.703	e	91	11.86	11.8	"	" 686	e	10	10.52	10.6
98	4431.558	i	10	10.64	10.5	"	6545.576	e	62	11.13	11.0	"	8010.636	i	10	10.12	11.5
"	4631.627	i	15	10.12	10.4	"	" .642	e	63	10.12	10.3	"	" 686	i	10	11.76	11.3
99	4674.640	i	14	11.70	11.4	"	6815.724	e	68	10.17	10.4	"	8011.671	i	10	12.31	12.0
"	4709.613	i	10	11.86	11.4	"	6817.705	e	55	11.13	11.1	"	8031.533	m	61	..	16.0
"	4711.690	i	12	11.23	11.2	05	7198.682	e	67	11.08	11.1	"	8033.547	m	60	..	15.8
"	4766.530	i	10	12.46	12.8	06	7275.630	e	64	11.13	11.2	"	8061.551	i	10	10.64	10.5
"	4784.563	i	20	12.23	12.2	"	7316.559	e	67	10.70	10.7	"	" 631	i	27	10.62	10.7
"	4914.816	i	10	12.46	12.4	"	7551.708	e	64	10.12	10.3	"	8063.535	i	10	11.08	10.8
00	5026.756	i	64	14.12	14.2	07	7598.720	e	59	11.08	11.2	"	" 609	i	10	10.74	10.4
"	5113.527	i	26	11.23	11.2	"	7644.593	e	66	10.12	10.5	"	" 553	e	30	10.12	10.5
01	5401.685	i	48	10.12	10.4	"	7941.848	e	84	10.17	10.4	"	8064.566	i	31	10.17	10.5
"	5673.860	e	109	11.13	11.1	08	7942.692	e	58	10.17	10.5	"	8071.605	i	10	11.96	11.8

indicating the instrument employed. The letter a denotes the 24-inch Bruce Telescope, e the 1-inch Cooke Anastigmat, i the 8-inch Draper Telescope, and m, Mr. Metcalf's 12-inch doublet. The time of exposure, in minutes, is given in the fourth column, and two measures of the photographic magnitude by Miss S. E. Breslin, in the fifth and sixth columns. The first of these measures was made by estimating the intervals in grades from the next brightest and next faintest star in the sequence given in Table I, the second was obtained by a direct comparison with the photographic magnitudes given in that table.

Additional independent estimates were made by Mrs. Fleming on the plates taken on J. D. 2414709.613, 2414711.690, 2416545.642, 2418006.624, 2418010.636 and 2418010.686, with the resulting magnitudes, 11.3, 11.0, 10.2, 12.5, 11.4 and 11.4, respectively.

Table IV contains a list of plates covering the region of the variable, but taken at times when the variable was too faint to appear on the plates. The year, omitting the two left hand figures, is given in the first column. The Julian Day, omitting the three left hand figures, 241, is given in the second column. The letter indicating the instrument, as in Table III, is given in the third column. The time of exposure in minutes is given in the fourth column. The fifth column gives the faintest star visible on the plate. Thus, the first plate taken, on J. D. 2410605, showed the star u, magnitude 13.9, but did not show w, magnitude 14.3. It was estimated that a star of the magnitude 14.0 would be visible, and as the variable did not appear it must have been fainter than that magnitude.

TABLE IV.
VARIABLE NOT SEEN.

Year.	J. D.	Inst.	Ex.	Magn.	Year.	J. D.	Inst.	Ex.	Magn.	Year.	J. D.	Inst.	Ex.	Magn.	Year.	J. D.	Inst.	Ex.	Magn.
			<i>m.</i>					<i>m.</i>					<i>m.</i>					<i>m.</i>	
87	0605	b	16	14.0	95	3235	i	15	12.8	99	5002	i	18	14.1	01	5506	e	69	11.6
89	1353	i	64	14.1	"	3526	i	15	13.9	"	"	e	70	11.0	"	5654	i	13	12.8
90	1430	i	11	13.7	96	3661	i	10	11.8	"	5018	e	102	12.6	"	5664	e	81	12.6
"	1432	i	16	13.7	97	3999	i	14	13.3	00	5336	i	12	12.9	"	5683	e	68	11.6
"	1731	i	22	13.9	97	4274	i	14	13.7	"	5367	e	91	13.2	02	5753	e	58	12.9
"	2078	i	13	12.9	98	4318	i	11	13.2	"	5383	i	15	14.1	"	5775	i	17	13.9
92	2119	i	10	12.7	99	4681	i	17	12.9	"	"	i	16	14.1	"	5786	e	60	13.7
"	2129	i	11	12.3	"	4682	i	12	14.1	01	5414	e	83	12.6	"	5793	e	64	12.8
93	2510	i	12	13.3	"	4755	e	67	12.3	01	5424	i	19	13.7	"	5795	i	12	14.0
"	2817	i	13	13.2	"	4949	e	74	12.8	"	"	e	97	13.2	"	"	e	84	13.9
94	2912	i	14	12.8	"	5001	e	81	11.6	"	5488	e	73	11.6	"	5810	e	66	11.6

Year.	J. D.	Inst.	Ex.	Magn.	Year.	J. D.	Inst.	Ex.	Magn.	Year.	J. D.	Inst.	Ex.	Magn.	Year.	J. D.	Inst.	Ex.	Magn.
02	5824	e	<i>m.</i> 80	12.7	04	6518	e	<i>m.</i> 73	12.1	05	6921	e	<i>m.</i> 60	11.6	06	7293	e	<i>m.</i> 66	12.8
"	5834	e	60	12.1	"	6523	e	83	13.2	"	6922	e	66	11.6	"	7294	e	63	12.8
"	5857	c	68	11.0	"	6569	e	58	11.6	"	6932	e	63	11.9	"	7321	e	66	10.7
"	6029	e	58	12.4	"	"	e	58	11.6	"	6936	e	74	12.8	"	7509	e	73	12.7
"	6048	e	40	12.8	"	6573	e	66	11.6	"	6942	e	57	12.8	"	7511	e	56	11.8
"	6073	e	97	11.7	"	6584	e	80	13.2	"	6953	e	62	11.0	"	7518	e	65	12.8
"	6093	e	69	13.2	"	6587	e	61	12.8	"	6955	e	67	10.9	"	7531	i	5	12.6
"	6115	e	78	13.7	"	6603	e	67	11.6	"	6960	e	47	10.7	"	"	e	64	12.8
03	6136	e	59	12.8	"	6605	e	64	11.6	"	7079	e	61	10.6	"	7548	e	67	11.6
"	6158	e	71	11.6	"	6717	e	42	10.9	"	7085	e	65	11.6	07	7582	e	60	10.4
"	6165	e	62	12.9	"	6760	e	81	13.2	"	7099	e	65	10.9	"	7613	e	62	12.3
"	6168	e	59	13.2	"	"	e	58	12.8	"	7102	e	60	11.6	"	7622	e	73	12.8
"	6169	i	19	13.9	"	6765	e	71	12.6	"	"	e	25	10.9	"	7625	e	60	12.2
"	6174	e	62	11.6	"	6770	e	70	11.9	"	7112	e	43	12.7	"	7630	e	69	13.2
"	6186	e	58	11.6	"	6776	e	60	12.3	"	7115	e	60	11.6	"	7632	e	62	11.6
"	6188	e	60	10.6	"	6778	e	94	10.9	"	"	e	58	12.1	"	7641	e	58	13.2
"	6189	e	70	12.2	"	6780	e	97	12.3	"	7117	e	64	11.6	"	7660	e	60	12.4
"	6217	e	62	11.7	"	6792	e	67	12.7	"	7122	e	60	12.1	"	7668	e	61	12.7
"	6225	e	62	12.6	"	6794	e	54	12.4	"	7123	e	60	12.2	"	7690	e	63	10.9
"	6234	e	67	10.9	"	6796	c	60	13.7	"	"	e	46	12.1	"	7865	e	59	12.6
"	6360	c	79	10.9	"	6802	e	59	13.2	"	7124	e	64	11.8	"	7871	e	63	11.8
"	6361	c	62	10.9	"	6806	e	56	11.6	"	7125	e	66	11.6	"	7893	e	62	13.3
"	6365	e	75	11.6	"	6822	e	62	13.2	"	7126	e	60	11.6	"	7934	e	88	12.8
"	6369	e	84	11.6	"	6824	e	63	12.9	"	7127	e	60	11.6	08	7968	e	62	11.6
"	6371	e	93	12.6	"	6826	e	54	13.2	"	"	e	17	11.0	"	8013	e	64	11.8
"	6372	e	110	11.6	"	6828	e	68	12.8	"	7131	e	62	12.1	"	8017	i	10	13.9
"	6383	e	46	10.9	"	6833	e	59	12.8	"	"	e	60	12.1	"	"	i	10	13.2
"	6388	e	63	11.8	"	6834	e	54	10.9	"	7132	e	61	12.1	"	8020	i	20	13.9
"	6406	e	75	13.2	05	6861	e	58	12.8	"	7149	e	83	11.0	"	"	i	20	13.8
"	6407	e	70	11.6	"	6874	e	63	13.2	"	7158	e	66	12.8	"	"	i	20	13.1
"	6416	e	67	12.8	"	"	e	74	13.7	"	7160	e	82	12.6	"	"	e	66	12.6
"	6422	e	91	12.3	"	6876	e	76	14.0	"	7181	e	75	11.6	"	8035	e	61	11.8
"	6431	e	70	11.6	"	6881	e	60	12.8	"	7208	e	60	11.8	"	8043	e	60	12.8
"	6434	e	81	12.1	"	6884	e	69	13.2	06	7235	c	59	12.9	"	8045	e	60	12.8
"	6439	e	77	13.2	"	6891	e	56	12.1	"	7236	e	93	13.9	"	8046	e	60	14.0
"	6463	e	73	12.3	"	"	e	60	11.8	"	7237	a	10	14.0	"	8048	e	60	11.8
"	6464	e	66	12.4	"	6902	e	64	13.2	"	7238	e	71	11.8	"	"	e	60	12.1
"	6472	e	59	12.3	"	6908	e	64	12.9	"	7252	e	71	11.8	"	8049	e	61	10.9
"	6475	e	61	13.2	"	"	e	93	11.6	"	7258	e	73	12.8	"	8061	i	60	12.1
"	6477	e	106	12.8	"	6916	i	10	12.9	"	7266	e	66	12.8	"	8074	i	11	13.2
04	6485	e	91	11.8	"	6918	a	10	14.2	"	7271	e	63	12.8	"	8076	i	9	12.8
"	6499	e	93	12.8	"	"	i	11	14.0	"	7291	e	76	12.3	"	8078	i	10	13.2
"	6504	e	58	13.2															

It appears from Table III that the maximum magnitude is 10.3, and the minimum probably, 15.9.

EDWARD C. PICKERING.

JULY 11, 1908.

HARVARD COLLEGE OBSERVATORY.

CIRCULAR 139.

—26° 179. A NEW VARIABLE OF THE CLASS OF β LYRAE. 003226.

FROM an examination of the Harvard Photographs, Miss Ida Whiteside, Assistant in Astronomy in Wellesley College, found that the star —26° 179, magnitude 9.1 was a variable, and has determined the nature of its variations, as described below. The method employed was that described in H. C. 29. The plate examined was taken with the 1-inch Cooke lens, at the Arequipa Station on September 7, 1901, and had nine exposures of 30' each. The star varies continuously, having two maxima, each magnitude 9.64, and two minima, magnitudes 10.47, and 9.84, respectively. The period is 0^d.511574. The star was measured on 195 plates. Of these 129 were taken at Arequipa, with the 1-inch Cooke lens, 33 were taken at Cambridge with a similar instrument, 2 were taken at Cambridge with the 8-inch Draper Telescope, and 31 were taken at Arequipa, with the 8-inch Bache Telescope. Six of the plates taken with the first of these instruments were similar to that on which the variable was found, so that in all 276 images of the star were measured, the first taken on January 3, 1891, the last on Oct. 31, 1907. The numbers in the successive years are, 1891, 3; 1892, 3; 1894, 1; 1895, 3; 1896, 3; 1897, 3; 1898, 2; 1899, 12; 1900, 32; 1901, 27; 1902, 22; 1903, 19; 1904, 29; 1905, 48; 1906, 45; 1907, 24. The observations from 1891 to 1899, and a few others, were made from plates taken with the 8-inch telescopes. While the residuals on the whole are larger than those from plates taken with the Cooke lenses, they do not show any systematic difference which would indicate a changing period, and the larger residuals are probably due to the plates having been taken with a different instrument, and that the scale was different. The mean of all the residuals is ± 0.10 of a magnitude. This star will be designated as H. V. 3085.

The designations, Durchmusterung numbers, right ascensions and declinations for 1900, and adopted photographic magnitudes of the comparison stars are given in Table I. They were found by the method described in H. C. 125. The Durchmusterung number and the position of the variable, for 1900, are given in the first line.

TABLE I.
COMPARISON STARS.

Desig.	C. DM.	R. A. 1900.	Dec. 1900.	Ptg.	Desig.	C. DM.	R. A. 1900.	Dec. 1900.	Ptg.
		<i>h. m. s.</i>	<i>° ' "</i>				<i>h. m. s.</i>	<i>° ' "</i>	
Var.	-26° 179	0 32 29.3	-26 6.5	..	f	-26° 197	0 34 58.5	-25 51.9	9.86
a	-26° 188	0 33 41.4	-26 0.0	7.43	g	-26° 181	0 33 7.6	-26 35.5	10.18
b	-25° 207	0 31 26.4	-25 18.3	7.75	h	-26° 189	0 33 46.3	-26 10.5	10.66
c	-25° 211	0 31 44.6	-25 39.9	9.01	k	-26° 186	0 33 28.9	-25 49.4	11.06
d	-25° 217	0 32 37.2	-25 38.4	9.78	l	-26° 178	0 32 11.9	-25 56.6	11.45
e	-26° 161	0 29 5.6	-26 12.5	9.84	m	-26° 184	0 33 15.3	-26 8.0	11.71

Table II, contains the results derived from the photographs. The first three columns give the year, the Julian Day and decimal, omitting the three left-hand figures, 241, and the photographic magnitude. The number of periods, E, and the phase computed from the formula $J. D. 2411736.114 + 0.511574 E$, and corrected for the velocity of light, are given in the fourth and fifth columns. The sixth column gives the residual obtained by subtracting the magnitude derived from the light curve from the observed magnitude given in the third column. Negative values are indicated by Italics.

TABLE II.
OBSERVATIONS.

Year.	Julian Day.	Magn.	E.	P.	R.	Year.	Julian Day.	Magn.	E.	P.	R.
1891	1736.436	9.95	0	.322	.15	"	4653.548	9.65	5702	.439	.15
"	1995.707	9.65	507	.230	.13	1899	4863.887	10.45	6114	.013	.11
1892	2223.905	9.90	953	.248	.07	"	4869.796	9.80	6125	.296	.03
"	2309.908	10.00	1121	.323	.20	"	4876.755	9.60	6139	.093	.08
"	2347.787	9.85	2203	.348	.10	"	4884.777	9.90	6154	.441	.10
1894	3026.868	10.30	2523	.046	.37	"	4904.700	9.50	6193	.411	.17
1895	3435.780	9.45	3322	.223	.30	"	4924.734	9.95	6232	.497	.28
"	3449.731	9.55	3349	.362	.18	"	4931.725	9.75	6246	.327	.04
"	3490.693	9.90	3429	.397	.24	"	4940.607	10.40	6263	.511	.07
1896	3751.843	9.75	3940	.130	.11	"	4979.623	9.65	6340	.132	.01
"	3840.644	9.75	4113	.432	.01	"	4980.625	9.50	6342	.111	.15
"	3876.632	9.95	4184	.086	.25	"	4990.638	9.55	6361	.404	.11
1897	4155.803	9.95	4729	.460	.01	"	4994.599	9.95	6369	.272	.10
"	4164.796	9.90	4747	.245	.07	1900	5226.847	9.80	6823	.267	.04
"	4183.783	10.00	4784	.305	.18	"	5232.809	9.70	6835	.090	.02
1898	4494.820	10.00	5392	.303	.18	"	5235.833	10.10	6841	.045	.14

Year.	Julian Day.	Magn.	E.	P.	R.	Year.	Julian Day.	Magn.	E.	P.	R.
1900	5261.726	9.85	6891	.362	.12	1901	5635.850	10.15	7623	.013	.15
"	5263.724	9.80	6895	.313	.01	"	5641.752	9.50	7634	.288	.33
"	5264.707	9.90	6897	.273	.05	"	5661.636	9.65	7673	.220	.10
"	5266.710	9.90	6901	.229	.15	"	5665.664	9.65	7681	.155	.01
"	5277.794	9.55	6932	.393	.10	"	5679.683	10.05	7708	.361	.32
"	5282.732	9.70	6983	.233	.08	"	5692.678	10.10	7734	.055	.25
"	5289.528	10.10	6946	.026	.02	"	5701.585	9.80	7751	.265	.04
"	" .549	9.95	6946	.047	.03	"	5717.453	9.85	7782	.274	.00
"	" .569	9.75	6946	.067	.02	"	5724.541	9.65	7796	.197	.05
"	" .590	9.75	6946	.088	.07	1902	5754.461	9.80	7854	.444	.00
"	" .611	9.60	6946	.109	.05	"	5915.888	9.80	8170	.214	.07
"	" .632	9.55	6946	.130	.09	"	5927.877	9.70	8193	.439	.08
"	" .653	9.55	6946	.151	.09	"	5928.843	9.55	8195	.382	.11
"	" .673	9.55	6946	.171	.10	"	5934.871	9.90	8207	.271	.05
"	" .693	9.55	6946	.191	.13	"	5942.836	9.85	8223	.051	.05
"	" .714	9.70	6946	.212	.03	"	5945.849	10.50	8227	.018	.27
"	" .735	9.70	6946	.233	.08	"	5976.814	9.70	8289	.268	.15
"	" .756	9.85	6946	.254	.02	"	6016.696	10.00	8367	.248	.17
"	" .777	9.75	6946	.275	.05	"	6017.788	9.65	8369	.317	.15
"	" .797	9.90	6946	.295	.07	"	6018.812	9.90	8371	.318	.10
"	" .818	9.90	6946	.316	.10	"	6022.607	10.30	8379	.020	.10
"	" .839	9.80	6946	.337	.02	"	6029.635	9.45	8392	.398	.21
"	" .860	9.70	6946	.358	.03	"	" .728	10.30	8392	.498	.09
"	" .880	9.65	6946	.378	.02	"	6032.586	9.95	8398	.279	.11
"	" .896	9.55	6946	.394	.10	"	6034.705	9.80	8402	.352	.05
"	5308.663	9.60	6983	.233	.18	"	6043.613	9.95	8420	.051	.05
"	5371.484	9.65	7108	.126	.00	"	6060.617	9.60	8453	.171	.05
1901	5589.842	10.15	7533	.044	.20	"	6073.559	9.65	8478	.325	.15
"	5599.768	9.90	7552	.252	.07	"	6080.615	9.80	8492	.217	.03
"	5604.829	9.50	7562	.197	.19	"	6086.584	9.95	8504	.046	.02
"	5609.777	10.40	7572	.029	.33	"	6100.559	9.60	8531	.208	.12
"	5613.820	10.35	7579	.492	.12	1903	6118.543	9.80	8566	.285	.03
"	5620.783	9.80	7593	.293	.03	"	6254.909	9.60	8833	.060	.20
"	5631.805	9.65	7613	.113	.00	"	6278.908	10.35	8880	.017	.10
"	5632.829	9.95	7617	.061	.15	"	6286.875	9.60	8895	.311	.21
"	5634.704	9.55	7620	.402	.11	"	6297.876	9.80	8917	.058	.02
"	" .834	10.30	7621	.020	.10	"	6302.840	9.70	8926	.419	.01
"	5635.685	9.40	7622	.360	.34	"	6313.828	9.85	8948	.153	.21
"	" .705	9.50	7622	.380	.17	"	6344.732	9.50	9008	.364	.22
"	" .725	9.50	7622	.400	.14	"	6345.788	9.65	9010	.397	.01
"	" .746	9.65	7622	.421	.05	"	6358.742	9.95	9038	.051	.05
"	" .767	9.70	7622	.442	.10	"	6360.768	10.15	9040	.030	.10
"	" .788	9.90	7622	.463	.05	"	6377.701	9.55	9073	.081	.15
"	" .809	10.05	7622	.484	.12	"	6400.724	9.50	9118	.084	.19
"	" .830	10.50	7622	.505	.10	"	6402.682	10.50	9121	.507	.09

Year.	Julian Day.	Magn.	E.	P.	R.	Year.	Julian Day.	Magn.	E.	P.	R.
1903	6407.681	9.90	9131	.390	.25	1905	7107.790	9.85	10500	.154	.21
"	6437.646	9.60	9190	.070	.15	"	7124.671	9.75	10533	.153	.11
"	6443.595	9.95	9201	.491	.27	"	7125.640	9.70	10534	.099	.04
"	6459.631	9.65	9233	.156	.01	"	7135.699	9.55	10554	.439	.23
"	6464.561	10.30	9242	.481	.17	"	7139.574	9.85	10562	.220	.10
1904	6494.548	9.85	9301	.272	.00	"	7144.531	9.70	10572	.061	.09
"	6647.849	9.75	9601	.113	.10	"	" .552	9.65	10572	.082	.05
"	6649.887	9.65	9605	.105	.01	"	" .572	9.65	10572	.102	.01
"	6663.879	9.95	9632	.286	.11	"	" .593	9.60	10572	.123	.05
"	6669.884	9.70	9644	.153	.06	"	" .614	9.60	10572	.144	.04
"	6682.840	9.80	9669	.321	.00	"	" .634	9.60	10572	.164	.04
"	6683.795	9.95	9671	.252	.12	"	" .655	9.60	10572	.185	.06
"	6685.844	9.80	9675	.255	.03	"	" .676	9.70	10572	.206	.01
"	6695.767	9.95	9694	.460	.01	"	" .697	9.75	10572	.227	.02
"	6705.747	9.70	9714	.205	.00	"	" .718	9.80	10572	.248	.03
"	6711.744	9.55	9726	.066	.22	"	" .738	9.80	10572	.270	.05
"	6725.692	9.70	9753	.202	.00	"	" .759	9.75	10572	.291	.08
"	6727.703	9.45	9757	.167	.20	"	7145.507	10.05	10574	.014	.09
"	" .756	9.90	9757	.219	.15	"	" .528	9.85	10574	.035	.15
"	6744.654	9.80	9790	.236	.00	"	" .549	9.75	10574	.056	.09
"	6752.758	9.60	9806	.155	.04	"	" .569	9.80	10574	.076	.08
"	6753.803	9.75	9808	.177	.09	"	" .590	9.75	10574	.097	.09
"	6754.711	9.75	9810	.061	.05	"	" .612	9.70	10574	.119	.05
"	" .776	9.85	9810	.127	.21	"	" .632	9.70	10574	.139	.06
"	6757.750	10.00	9816	.031	.05	"	" .653	9.70	10574	.160	.06
"	6761.595	9.65	9823	.298	.17	"	" .674	9.75	10574	.181	.09
"	6781.586	9.65	9862	.334	.13	"	" .695	9.85	10574	.202	.15
"	6782.670	9.60	9864	.395	.05	"	" .716	9.90	10574	.223	.15
"	6785.616	9.90	9870	.271	.05	"	" .736	9.90	10574	.243	.09
"	6786.535	9.70	9872	.167	.05	"	7151.616	10.45	10585	.496	.17
"	6793.660	9.50	9888	.129	.14	"	7154.615	9.90	10591	.426	.18
"	6802.574	9.85	9903	.347	.09	"	7168.597	9.70	10619	.082	.05
"	6810.573	9.65	9919	.169	.00	"	7177.540	9.75	10636	.328	.04
"	6822.562	9.55	9942	.381	.11	"	7194.670	9.65	10670	.062	.14
1905	6851.472	9.65	9999	.128	.01	"	7195.544	9.90	10671	.425	.18
"	6858.543	9.95	10013	.037	.03	1906	7242.540	9.85	10763	.352	.10
"	7010.874	9.85	10310	.443	.09	"	7356.889	9.70	10987	.110	.05
"	7020.902	10.05	10330	.220	.30	"	7405.824	9.90	11082	.450	.06
"	7052.880	10.40	10392	.493	.15	"	7413.848	9.70	11098	.290	.13
"	7053.808	9.70	10394	.398	.04	"	7422.803	9.80	11116	.036	.19
"	7065.824	9.55	10418	.136	.09	"	" .850	9.60	11116	.083	.10
"	7069.758	10.50	10425	.490	.29	"	7432.794	9.60	11135	.308	.21
"	7080.698	9.60	10447	.176	.05	"	7444.835	9.85	11159	.072	.11
"	7095.704	9.55	10476	.347	.11	"	7465.786	9.85	11200	.049	.05
"	7098.701	9.75	10482	.274	.10	"	7469.652	9.80	11207	.334	.01

Year.	Julian Day.	Magn.	E.	P.	R.	Year.	Julian Day.	Magn.	E.	P.	R.
1906	7476.539	9.85	11221	.059	.04	1906	7528.637	10.55	11324	.486	.38
"	" .560	9.85	11221	.080	.15	"	7747.885	9.80	11751	.266	.04
"	" .581	9.70	11221	.101	.04	"	7767.841	9.95	11790	.275	.10
"	" .602	9.65	11221	.122	.00	"	7774.810	9.65	11804	.080	.05
"	" .623	9.60	11221	.143	.04	1907	7806.821	9.80	11866	.375	.12
"	" .643	9.65	11221	.163	.01	"	7815.739	9.85	11884	.085	.06
"	" .664	9.70	11221	.184	.04	"	7817.793	9.60	11888	.093	.08
"	" .685	9.80	11221	.205	.10	"	7820.813	9.75	11894	.043	.19
"	" .705	9.70	11221	.225	.05	"	7833.775	9.85	11919	.216	.11
"	" .726	9.75	11221	.246	.07	"	7848.790	9.60	11948	.396	.05
"	" .747	9.75	11221	.267	.10	"	7853.507	10.50	11957	.509	.06
"	" .768	9.75	11221	.288	.08	"	" .528	9.95	11958	.018	.30
"	" .788	9.70	11221	.308	.11	"	" .549	9.85	11958	.039	.12
"	" .809	9.65	11221	.329	.14	"	" .570	9.80	11958	.060	.00
"	" .830	9.70	11221	.350	.05	"	" .591	9.70	11958	.081	.00
"	" .851	9.70	11221	.371	.01	"	" .611	9.65	11958	.101	.01
"	7490.707	9.90	11248	.415	.22	"	" .632	9.60	11958	.122	.05
"	7492.706	9.90	11252	.367	.19	"	" .653	9.70	11958	.143	.06
"	7496.701	9.95	11260	.270	.10	"	" .673	9.75	11958	.163	.11
"	7501.554	10.35	11270	.006	.04	"	" .694	9.85	11958	.184	.18
"	" .575	9.90	11270	.027	.19	"	" .715	9.90	11958	.205	.20
"	" .596	9.80	11270	.047	.11	"	" .736	9.95	11958	.226	.18
"	" .616	9.70	11270	.068	.06	"	7864.669	9.90	11979	.416	.22
"	" .637	9.65	11270	.089	.03	"	" .712	9.90	11980	.459	.03
"	" .657	9.65	11270	.109	.00	"	7873.671	9.75	11995	.231	.03
"	" .678	9.70	11270	.130	.06	"	7879.647	9.95	12009	.045	.02
"	" .668	9.90	11305	.214	.16	"	7880.658	10.00	12011	.033	.02
"	7525.661	9.85	11317	.067	.09						

The observed magnitude, 10.95, on J. D. 7392.849, gave the residual 1.11, and has been rejected since the photographic image is defective.

A light curve was constructed by grouping the observed magnitudes for each one hundredth of a day. The result is shown in Figure 1. A smooth curve was drawn through these points, and the coördinates for intervals of $0^d.025$ are given in Table III. The curve shows that the star belongs to

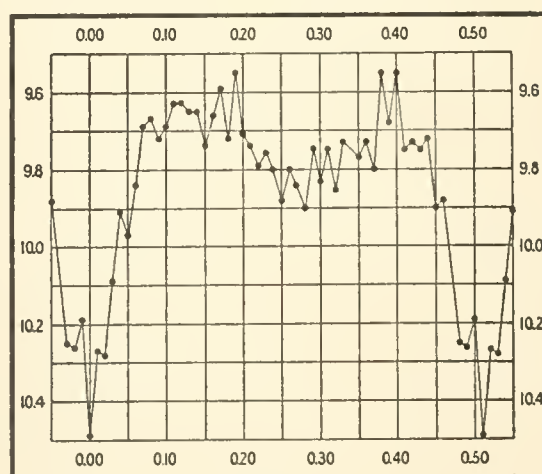


FIG. 1.

the somewhat rare class of variables, of which β Lyrae may be regarded as typical. The first maximum is flatter and of longer duration than the second. An examination of a photograph taken with the 8-inch Bache Telescope, at Arequipa, on September 18, 1897, shows that the spectrum is of Class F, or intermediate between Types I and II.

TABLE III.

LIGHT CURVE.

Phase.	Magn.	Phase.	Magn.	Phase.	Magn.	Phase.	Magn.	Phase.	Magn.
.000	10.47	.100	9.66	.200	9.70	.300	9.82	.400	9.65
.025	10.14	.125	9.65	.225	9.77	.325	9.80	.425	9.70
.050	9.90	.150	9.64	.250	9.82	.350	9.75	.450	9.85
.075	9.72	.175	9.66	.275	9.84	.375	9.67	.475	10.07

Table IV gives the correction for the velocity of light, or the amount to be added to the observed time, to give the heliocentric time of primary minimum. The limiting dates are given in the first column, and the corresponding correction in the second column.

TABLE IV.

LIGHT EQUATION.

Dates.			Corr.	Dates.			Corr.	Dates.			Corr.
Jan.	3 - Jan.	13	-.002	May	30 - June	10	-.001	Oct.	19 - Nov.	5	+.004
Jan.	14 - Jan.	26	-.003	June	11 - June	21	.000	Nov.	6 - Nov.	19	+.003
Jan.	27 - Feb.	13	-.004	June	22 - July	4	+.001	Nov.	20 - Nov.	30	+.002
Feb.	14 - Apr.	15	-.005	July	5 - July	15	+.002	Nov.	31 - Dec.	11	+.001
April	16 - May	3	-.004	July	16 - July	30	+.003	Dec.	12 - Dec.	21	.000
May	4 - May	18	-.003	July	31 - Aug.	11	+.004	Dec.	22 - Jan.	2	-.001
May	19 - May	29	-.002	Aug.	12 - Oct.	18	+.005				

An ephemeris giving the Greenwich Mean Time of the minima occurring during July, 1908, is given in Table V. The first two columns give the value of E , and the Julian Day and decimal following Greenwich Mean Noon of the principal

minimum computed by the formula given on page 2. The calendar date and Greenwich Mean Time are given in the third column.

TABLE V.

EPIHEMERIS.

E.	J. D.	G. M. T.			E.	J. D.	G. M. T.			E.	J. D.	G. M. T.					
			<i>d.</i>	<i>h.</i>	<i>m.</i>				<i>d.</i>	<i>h.</i>	<i>m.</i>				<i>d.</i>	<i>h.</i>	<i>m.</i>
12487	8124.138	July	1	3	19	12507	8134.369	July	11	8	52	12527	8144.601	July	21	14	26
12488	8124.649	"	1	15	34	12508	8134.880	"	11	21	7	12528	8145.112	"	22	2	42
12489	8125.161	"	2	3	52	12509	8135.392	"	12	9	24	12529	8145.624	"	22	14	58
12490	8125.672	"	2	16	8	12510	8135.904	"	12	21	42	12530	8146.135	"	23	3	14
12491	8126.184	"	3	4	25	12511	8136.416	"	13	9	59	12531	8146.647	"	23	15	32
12492	8126.695	"	3	16	41	12512	8136.927	"	13	22	15	12532	8147.158	"	24	3	48
12493	8127.207	"	4	4	58	12513	8137.439	"	14	10	32	12533	8147.670	"	24	16	5
12494	8127.718	"	4	17	14	12514	8137.950	"	14	22	48	12534	8148.182	"	25	4	22
12495	8128.230	"	5	5	31	12515	8138.462	"	15	11	6	12535	8148.694	"	25	16	40
12496	8128.741	"	5	17	47	12516	8138.973	"	15	23	21	12536	8149.205	"	26	4	55
12497	8129.253	"	6	6	4	12517	8139.485	"	16	11	38	12537	8149.717	"	26	17	12
12498	8129.765	"	6	18	22	12518	8139.996	"	16	23	54	12538	8150.228	"	27	5	28
12499	8130.277	"	7	6	39	12519	8140.508	"	17	12	12	12539	8150.740	"	27	17	46
12500	8130.788	"	7	18	55	12520	8141.019	"	18	0	28	12540	8151.251	"	28	6	2
12501	8131.300	"	8	7	12	12521	8141.531	"	18	12	44	12541	8151.763	"	28	18	19
12502	8131.810	"	8	19	26	12522	8142.043	"	19	1	2	12542	8152.274	"	29	6	34
12503	8132.323	"	9	7	45	12523	8142.555	"	19	13	19	12543	8152.786	"	29	18	52
12504	8132.834	"	9	20	1	12524	8143.066	"	20	1	35	12544	8153.297	"	30	7	8
12505	8133.346	"	10	8	18	12525	8143.578	"	20	13	52	12545	8153.809	"	30	19	25
12506	8133.857	"	10	20	34	12526	8144.089	"	21	2	8	12546	8154.321	"	31	7	42

EDWARD C. PICKERING.

JULY 13, 1908.

HARVARD COLLEGE OBSERVATORY,

CIRCULAR 140.

16 NEW VARIABLE STARS IN HARVARD MAP, Nos. 4 AND 13.

Nos. 4 and 13 of the Harvard Map have been examined for variable stars, by Miss Cannon. Four new variable stars were found in H. M. 4, besides the known variables, T Camelopardi, X Camelopardi, 044068, S Camelopardi, V Camelopardi, Z Aurigae, X Aurigae, R Lynceis, RU Camelopardi, and Y Camelopardi. Twelve new variable stars were found in H. M. 13, besides the known variables, RX Aurigae, RW Aurigae, 050442, W Aurigae, Y Aurigae, U Aurigae, U Orionis, 055020, 060426, RT Aurigae, 062938, and X Geminorum. In the latter region, Nova Geminorum, the planet Neptune, and the minor planet Ceres, were also found. The star 060426 shows undoubted variability of at least one magnitude, on these plates. No letter has yet been assigned to this variable, although it was announced by Backhouse in 1897, and confirmed by Wendell with a range of 0.94 magn. See H. A. 55, 38.

At the beginning of this investigation, there were 24 known variables in the region of H. M. 4, and 38 in the region of H. M. 13, brighter than magnitude 10.5 at maximum. Assuming the proportion that the number of known variables found is to the total number found, as the number already known to exist in the region is to the entire number in the region, it follows that in H. M. 4, there are probably 34 variable stars of which 28, or 0.82, have been found, and in H. M. 13, there are probably 76, of which 50, or 0.66, have been found.

The new variable stars are given in Table I, in which the successive columns give the designation, the Harvard number, the constellation, the number in the Bonn Durchmusterung, the right ascension for 1900, the declination for 1900, the brightest observed magnitude, the faintest observed magnitude, the range of variation so far observed, and the class to which the variable belongs.

TABLE I.
NEW VARIABLE STARS.

Desig.	H. V.	Constellation.	DM.	R. A. 1900.			Dec. 1900.	Bright.	Faint.	Range.	Class.
				<i>h.</i>	<i>m.</i>	<i>s.</i>	<i>°</i>				
050840	3086	Auriga	+39° 1225	5	8	14	+40 1.0	9.3	10.1	0.8	IV?
053538	3087	Auriga	..	5	35	2	+38 53.2	9.5	<12	>2.5	II
053913	3088	Taurus	+13° 971	5	39	23	+13 31.9	8.5	9.4	0.9	IV
054319	3089	Taurus	..	5	43	12	+19 2.0	10.0	<15	>5	II?
054528	3090	Auriga	+28° 921	5	45	49	+28 5.2	9.4	11.0	1.6	IV
054945	3091	Auriga	+45° 1202	5	49	42	+45 29.1	9.3	10.3	1.0	..
055013	3092	Orion	+13° 1034	5	50	11	+13 40.2	9.7	10.7	1.0	V
055424	3093	Taurus	+24° 1056	5	54	33	+24 28.1	9.3	10.3	1.0	V?
055622	3094	Gemini	+22° 1146	5	56	35	+22 14.7	9.5	11.0	1.5	IV
055716	3095	Orion	..	5	57	16	+16 22.3	9.5	<12	>2.5	II?
060222	3096	Gemini	+22° 1187	6	2	32	+22 37.9	9.0	10.0	1.0	IV?
062061	3097	Lynx	+61° 887	6	20	24	+61 37.1	9.2	9.9	0.7	..
062220	3098	Gemini	..	6	22	..	+20 37	9.6	10.5	0.9	V
062367	3099	Camelopardus	..	6	23	40	+67 6.0	10.6	<11.6	>1.0	..
070473	3100	Camelopardus	..	7	4	9	+73 29.7	9.8	10.9	1.1	V?
080165	3101	Ursa Major	+65° 613	8	1	41	+65 31.6	9.2	10.1	0.9	..

REMARKS.

050840. The variability was confirmed by an examination of 20 photographs, taken between January 25, 1893 and February 8, 1908. The period is probably short.

053538. An examination of this star on 84 photographs, taken between December 29, 1890 and March 12, 1908, shows that it is a variable star of long period. These observations are represented by the formula for the times of maxima, $J. D. 2416792 + 452 E$.

053913. The variability was confirmed by an examination of 15 photographs, taken between November 3, 1891 and January 31, 1908. The period is short. The variable was at minimum on January 14, 1905, but on January 28, 1905, it was at maximum.

054319. This star has been examined on 82 photographs, taken between December 15, 1898 and January 10, 1908. The variation is large, but it appears uncertain whether the star belongs to Class II, variables of long period, or is peculiar, and resembles R Coronae Borealis. Photographs taken with the Bruce telescope, on October 11, 1899 and November 16, 1904, show no trace of this star, although stars as faint as the fifteenth magnitude are seen. The maximum appears to continue for a long period. Thus, 11 photographs taken between September 24,

1901 and March 1, 1902, 10 between October 2, 1902 and February 26, 1903, 8 between October 2, 1903 and January 15, 1904, and 12 between August 31, 1905 and March 23, 1906, show the star near maximum brightness.

054528. The variation was confirmed by an examination of 12 photographs, taken between December 15, 1898 and January 31, 1908. The period is short.

054945. This star was examined on 12 photographs, taken between December 11, 1889 and January 29, 1906. The nature of the light curve is not indicated. The star is probably red in color, since the magnitude 8.5, in the Bonn Durchmusterung, indicates that the star is brighter visually than would be inferred from its photographic magnitude at maximum.

055013. This is a variable star of the Algol type. It was at or near minimum on 9 of 187 photographs, taken between December 15, 1898 and February 22, 1908. On 7 photographs it is slightly fainter than normal, and on the remaining 171, it is of normal brightness.

055424. This variable is faint on 3 of 24 photographs, taken between December 29, 1899 and January 31, 1908. The variability is probably of the Algol type.

055622. Near border of Orion. The variability was confirmed by an examination of 16 photographs, taken between February 4, 1893 and January 30, 1908. The period is short.
055716. The variability was confirmed by an examination of 15 photographs, taken between December 29, 1890 and November 16, 1904. On February 22, 1891, December 12, 1899, and November 16, 1904 the magnitude of this star was 9.5. It was fainter than magnitude 12 on January 1, 1899, March 10, 1900, and February 7, 1901. The period is probably long.
060222. The variability was confirmed by an examination of 12 photographs, taken between January 6, 1900 and December 28, 1904. The period is probably short.
062061. The variability was confirmed by an examination of 19 photographs, taken between February 19, 1891 and January 25, 1906. The character of the light curve is not indicated.
062220. This star precedes $+20^{\circ} 1432$, magn. 9.5, about $0^m.1$, south $1'.5$. The variability was confirmed by an examination of 76 photographs, taken between March 3, 1890 and February 8, 1908. The light is at or near normal on all of the photographs, except five. The variability is probably of the Algol type. The star was faint on October 25, 1901, February 6, 1902, November 9, 1903, January 29, 1906, and March 18, 1908.
062367. The variability was confirmed by an examination of 15 photographs, taken between February 23, 1893 and October 27, 1906.
070473. This star follows $+73^{\circ} 366$, magn. 7.5, 24^s , north $0'.5$. The variability was confirmed by an examination of 34 photographs, taken between March 8, 1890 and January 25, 1906. The variable is fainter than normal on 5 of these plates. It is probably of the Algol type. It was faint on December 22, 1903, but on December 23, 1903, the light was normal.
080165. The variability was confirmed by the examination of 12 photographs, taken between March 8, 1890 and January 25, 1906.

JULY 13, 1908.

EDWARD C. PICKERING.

HARVARD COLLEGE OBSERVATORY.

CIRCULAR 141.

29 NEW VARIABLE STARS NEAR NOVA SAGITTARII.

In the study of the distribution of variable stars now in progress at this Observatory, an important line of research has for its object the discovery of groups of faint variables. At present, the most remarkable regions known are certain globular clusters, the Nebula of Orion, and the Magellanic Clouds. The investigation here referred to does not include the globular clusters. The photographs employed were taken with the 24-inch Bruce Telescope and have long exposures, preferably two hours, or more. The choice of the particular region to be examined at any time is guided principally by the number and quality of photographs available for comparison, preference being given to regions which are in themselves especially interesting. No attempt has been made to follow any consecutive order.

The region near Nova Sagittarii has recently been examined, by Miss Leavitt, on three Bruce plates having their centres for 1855, in R. A. = $18^h 49^m$, Dec. = $-12^\circ.5$; R. A. = $18^h 54^m$, Dec. = $-12^\circ.2$; R. A. = $18^h 55^m$, Dec. = $-13^\circ.4$. The corresponding plates, dates, and exposures are A 2845, October 23, 1897, 60^m ; A 4091, October 26, 1899, 150^m ; A 5712, October 10, 1901, 180^m . No two of the plates have the same centre. The region common to the three extends in right ascension, from $18^h 42^m$ to $19^h 2^m$, and in declination from $-10^\circ.9$ to $-14^\circ.7$, while the extreme limits of the region which may be compared on any two plates are $18^h 41^m$ and $19^h 7^m$ in right ascension, and $-10^\circ.0$ and $-15^\circ.0$ in declination. As there is much difficulty in comparing star images on superposed Bruce plates when the centres are a degree or more apart, it is not probable that all stars showing variation on these plates were discovered. Nevertheless, a surprising number of faint variables was found. The material existing for their confirmation is scanty, consisting principally of the three Bruce plates above mentioned, and three plates taken with the 8-inch Bache Telescope. The designations, dates, and exposures of these plates are, B 23759, August 2, 1899, 153^m ; B 32278, July 17, 1903, 60^m ; B 32341, July 28, 1903, 60^m . Seven other Bache plates were examined for a few

of the brightest variables. Nova Sagittarii and the known variable, ST Sagittarii, were re-discovered. The stars which show well-defined changes, and are certainly bright on at least two plates, and certainly faint on at least two, are given in Table I. The first five columns give the designation, the Harvard number, the constellation, the right ascension for 1900, and the declination for 1900. The sixth to the eleventh columns give the observations on the six plates described above. The range is given in the last column. As a rule, only two estimates of the actual magnitudes were made, but each variable was looked for on each plate and recorded

TABLE I.
NEW VARIABLES.

Design.	H. V.	Constellation.	R. A. 1900.			Dec. 1900.	A 2845.	B 23759.	A 4091.	A 5712.	B 32278.	B 32341.	Range.	
			<i>h.</i>	<i>m.</i>	<i>s.</i>	<i>°</i>	<i>'</i>							
184414	3102	Scutum	18	44	38	-14	16.2	<15.8	Ft.	15.4	<16.2	Ft.	..	>0.8
184510	3103	Scutum		45	2	-10	50.1	14.0	Br.	Br.	15.0	Br.	Ft.	1.0
184513	3104	Scutum		45	56	-13	2.6	13.2	14.0	..	10.0	Br.	Br.	4.0
184712a	3105	Scutum		47	16	-12	37.9	13.4	Ft.	Br.	15.0	Br.	Ft.	1.6
184712b	3106	Scutum		47	35	-12	53.7	Ft.	Ft.	15.2	<16.0	Br.	Br.	>0.8
184814	3107	Scutum		48	1	-14	19.1	15.4	..	12.0	14.0	Ft.	..	3.4
184812b	3108	Scutum		48	15	-12	38.5	15.0	Br.	<16.0	15.8	Br.	Br.	>1.0
184812c	3109	Scutum		48	16	-12	46.3	Ft.	12.0	15.2	<16.0	Br.	Ft.	>4.0
184911	3110	Scutum		49	14	-11	5.8	13.6	Ft.	Ft.	15.5	Br.	..	1.9
184912	3111	Scutum		49	15	-12	18.8	15.4	Br.	Ft.	14.4	Ft.	Ft.	1.0
185110	3112	Scutum		51	39	-10	46.2	13.7	Br.	..	14.6	Ft.	Ft.	0.9
185212	3113	Scutum		52	26	-12	35.4	15.8	Ft.	<16.0	14.7	Br.	..	>1.3
185315	3114	Scutum		53	20	-15	8.7	15.2	Br.	..	14.0	Ft.	Br.	1.2
185313	3115	Sagittarius		53	36	-13	26.7	Ft.	Ft.	13.9	<15.8	Br.	..	>1.9
185312	3116	Sagittarius		53	57	-12	6.8	<15.8	Ft.	15.0	15.7	Br.	14.5	>1.3
185411	3117	Aquila		54	52	-11	37.7	15.8	14.8	Ft.	15.0	Ft.	..	1.0
185511	3118	Aquila		55	30	-11	3.5	13.5	Ft.	Br.	14.5	Ft.	Ft.	1.0
185512b	3119	Sagittarius		55	38	-12	38.3	Ft.	Ft.	15.0	15.8	Br.	Br.	0.8
185612	3120	Sagittarius		56	30	-12	36.8	Br.	..	<16.0	15.0	Ft.	Ft.	>1.5
185712	3121	Sagittarius		57	33	-12	16.0	Ft.	Ft.	14.4	<15.8	Br.	Br.	>1.4
185814	3122	Sagittarius		58	16	-14	0.9	15.2	Ft.	Br.	12.1	..	Ft.	3.1
185813	3123	Sagittarius		58	35	-13	1.6	Br.	Br.	13.4	14.2	Ft.	Ft.	0.8
185912	3124	Sagittarius		59	56	-12	50.8	<15.8	Br.	16.0	12.0	Ft.	Ft.	4.0
190112a	3125	Sagittarius	19	0	58	-12	25.7	Ft.	Br.	<16.0	15.2	Ft.	Ft.	>0.8
190112b	3126	Sagittarius		1	4	-12	29.7	<15.9	Ft.	15.2	15.6	Br.	..	>0.7
190112c	3127	Sagittarius		1	14	-12	3.9	Ft.	Ft.	15.0	15.8	15.0	Br.	0.8
190312	3128	Sagittarius		3	23	-12	30.7	12.8	10.5	Br.	15.8	Br.	..	5.3
190612	3129	Sagittarius		6	51	-12	37.6	..	Ft.	15.2	16.0	Br.	..	0.8
190810	3130	Aquila		7	58	-10	35.2	..	..	14.5	<15.5	..	..	>1.0

as bright or faint. The reason for printing these rough observations is the probability that it may be a considerable time before a sufficient number of photographs can be obtained for the detailed study of the variables.

On Plate B 30495, taken July 30, 1902, exposure 60^m , the magnitude of *185612* was estimated as 14.5.

A list of 22 stars which seem to be certainly variable, but for which there are at present too few plates for confirmation, is given in Table II. The form is nearly the same as that of Table I, except that the designation and Harvard number are omitted.

TABLE II.
SUSPECTED VARIABLES.

Constellation.	R. A. 1900.			Dec. 1900.		A 2845.	B 23759.	A 4091.	A 5712.	B 32278.	B 32341.	Range.
	<i>h.</i>	<i>m.</i>	<i>s.</i>	<i>°</i>	<i>'</i>							
Scutum	18	44	44	-14	42.7	15.0	..	15.7	Br.	Br.	Br.	0.7
Scutum		45	45	-12	30.5	Ft.	Ft.	15.2	<15.9	Br.	..	>0.7
Scutum		47	14	-12	43.3	Ft.	Ft.	15.3	15.8	Br.	Ft.	0.5
Scutum		47	41	-11	57.3	Br.	..	15.5	15.9	Br.	..	0.4
Scutum		48	48	-13	58.9	Br.	..	15.2	15.8	..	Br.	0.6
Scutum		49	47	-12	54.7	15.0	Ft.	14.3	Ft.	Ft.	..	0.7
Scutum		50	16	-13	21.1	15.3	Ft.	14.8	Ft.	Ft.	..	0.5
Scutum		51	2	-10	41.5	13.7	Br.	..	14.5	Ft.	Ft.	0.8
Scutum		51	20	-14	47.7	Br.	Br.	15.7	15.2	Br.	Br.	0.5
Scutum		52	7	-13	2.8	14.2	Ft.	Ft.	15.5	Ft.	Ft.	1.3
Aquila		53	58	-11	43.3	Ft.	Ft.	15.2	16.0	Ft.	..	0.8
Sagittarius		55	33	-14	6.6	Br.	..	15.2	<16.0	..	..	>0.8
Sagittarius		55	55	-14	33.0	15.2	Br.	Br.	15.8	Br.	..	0.6
Sagittarius		55	57	-14	7.4	Ft.	..	13.6	14.0	..	..	0.4
Sagittarius		56	18	-13	4.7	<15.0	Ft.	15.5	14.0	Ft.	..	1.5
Sagittarius		58	10	-13	50.4	Ft.	Ft.	15.0	15.6	..	Ft.	0.6
Sagittarius		59	4	-14	8.5	..	Ft.	15.5	15.0	Br.	..	0.5
Sagittarius		59	5	-15	9.0	14.3	Ft.	Ft.	13.0	Ft.	Ft.	1.3
Sagittarius		59	21	-12	8.1	Ft.	Ft.	14.8	<15.8	Ft.	Ft.	>1.0
Sagittarius	19	0	59	-12	29.5	Ft.	Ft.	<16.0	16.0	Ft.	14.0	>2.0
Sagittarius		3	54	-14	37.6	..	Ft.	15.8	14.8	Ft.	Ft.	1.0
Sagittarius		5	37	-13	40.4	..	..	15.8	15.0	..	..	0.8

REMARKS.

h. m. s.

18 44 44. This star is certainly fainter on A 4091 than on the other plates.

18 45 45. A fifteenth magnitude star follows about $0^{\circ}.5$.

18 59 21. A sixteenth magnitude star is about $3''$ south.

h. m. s.

19 0 59. This star was noticed as bright on B 32341, while observing the variable *190112b*, given in Table I. It seems to show slight fluctuations on other plates.

The number of variables contained in the two tables is 51, and it should be observed that it is undoubtedly only the small number of plates available which prevents the majority of the objects in Table II from being confirmed as certainly variable. In brightness and range, these variables are comparable with those in the Magellanic Clouds. The large number discovered causes the region to be of special interest. Among other regions rich in faint stars may be mentioned those surrounding the Nebula in Carina, the Trifid Nebula, and the Great Spiral Nebula in Cygnus, whose most conspicuous portions are known as N. G. C. 6960 and N. G. C. 6992. Each of these regions has been examined on a larger number of plates of excellent quality than were available for the locality under discussion, with results given in Circulars 79, 91, 107, and 115, respectively. Sixteen variables were found in Cygnus and sixteen near the Trifid Nebula, while thirty-two were found in Carina on six plates, all of which have the same centre. The region surrounding Nova Sagittarii appears to exceed all of these in its richness in variable stars.

EDWARD C. PICKERING.

JULY 22, 1908.

HARVARD COLLEGE OBSERVATORY.

CIRCULAR 142.

28 NEW VARIABLE STARS IN HARVARD MAP, NOS. 30 AND 33.

AN examination, by Miss Leavitt, of Harvard Map, Nos. 30 and 33, has led to the discovery of 28 new variables. A summary of the results is contained in Table I, in which the successive columns give the number of the plate in the Harvard Map, the approximate right ascension and declination of the centre, the number of new variables discovered, the total number found, the proportion which is new, the whole number known, the probable number, the proportion of the probable number found, the probable number unknown, and the probable proportion unknown. The method of determining these various quantities is described in Circular 130.

TABLE I.
NUMBER AND DISTRIBUTION OF VARIABLES.

No.	Region.		New Variables.	Total Found.	Proportion New.	All.	Probable Number.	Proportion Found.	Probable No. Unknown.	Proportion Unknown.
30	<i>h.</i>	<i>°</i>	13	16	.93	23	112	.12	91	.81
33	16	0	15	18	.83	27	72	.25	45	.61

A list of the new variables is given in Table II. The designation, in the first column, is followed by the Harvard number, the constellation, the number in the Bonn Durchmusterung, the right ascension and declination for 1900, the brightest and faintest magnitudes observed, and the range. The known variables, R Serpentis, U Herculis, RU Librae, RR Aquarii, V Pegasi, and T Pegasi, were rediscovered.

The total number of stars in H. M. 30 is estimated as 14,000, and in H. M. 33, as 27,000. The number of known variables, therefore, in H. M. 30 is about one in 600, and in H. M. 33, one in 1,000. The total numbers of variables are probably one in 125, in H. M. 30, and one in 375, in H. M. 33. The proportion of variables

as faint at maximum as the tenth magnitude is unusually large. This should be remembered when comparing these proportions, and those given in Table I, with the corresponding results given in previous Circulars.

The variable *034946*, H. V. 3040, announced in H. C. 135, was rediscovered by Mrs. Fleming, June 11, 1908, by means of its photographic spectrum, which was classified by her as Md 9 on Plate A 8551, taken November 13, 1907. It was then found that the eleventh magnitude star which follows 9^s had been measured and announced by mistake for the variable. The true position of the variable is in R. A. = 3^h 49^m 36^s, Dec. = -46° 7'.9 (1900).

TABLE II.
NEW VARIABLES.

Design.	H. V.	Constellation.	DM.	R. A. 1900.			Dec. 1900.		Bright.	Faint.	Range.
				<i>h.</i>	<i>m.</i>	<i>s.</i>	<i>°</i>	<i>'</i>			
150801	3131	Serpens	- 1° 3036	15	8	50	- 1	31.1	9.4	10.2	0.8
151102	3132	Serpens	+ 2° 2940	15	10	58	+ 2	32.5	10.1	10.9	0.8
152602	3133	Serpens	+ 2° 2972	15	26	0	+ 2	0.8	9.3	10.1	0.8
154315	3134	Libra	-15° 4194	15	43	26	-15	13.9	9.6	10.6	1.0
161106	3135	Ophiuchus	- 6° 4393	16	11	6	- 6	43.8	9.2	10.0	0.8
161206	3136	Ophiuchus	..	16	12	34	- 6	24.9	10.5	11.2	0.7
161402	3137	Serpens	..	16	14	5	- 2	15.4	8.9	14.5	5.6
162411	3138	Ophiuchus	-11° 4154	16	24	20	-11	48.6	9.5	10.2	0.7
163113	3139	Hercules	+13° 3174	16	31	32	+13	30.6	9.8	10.6	0.8
164012	3140	Hercules	+12° 3081	16	40	55	+12	19.0	9.4	<11.0	>1.6
164403	3141	Ophiuchus	+ 3° 3281	16	44	38	+ 3	48.6	9.8	11.1	1.3
165202	3142	Ophiuchus	..	16	52	39	- 2	36.4	9.6	<11.0	>1.4
165905	3143	Ophiuchus	..	16	59	5	+ 5	7.7	10.2	11.2	1.0
211000	3144	Aquarius	..	21	10	11	- 0	19.6	10.0	11.0	1.0
211102	3145	Aquarius	- 2° 5494	21	11	11	- 2	38.7	11.0	<12.0	>1.0
211411	3146	Aquarius	-11° 5574	21	14	51	-11	13.5	9.2	10.2	1.0
211707	3147	Aquarius	..	21	17	46	- 7	30.4	11.0	<12.5	>1.5
211800	3148	Aquarius	+ 0° 4716	21	17	58	+ 0	24.4	11.0	<12.5	>1.5
213102	3149	Pegasus	..	21	31	6	+ 2	47.1	10.7	11.7	1.0
214012	3150	Pegasus	+12° 4678	21	40	15	+12	13.3	9.8	<12.0	>2.2
214505	3151	Aquarius	- 5° 5649	21	45	31	- 5	35.4	10.8	12.0	1.2
221302	3152	Pegasus	+ 2° 4488	22	13	5	+ 2	14.2	9.8	10.6	0.8
221313	3153	Pegasus	+12° 4801	22	13	24	+13	5.2	10.0	11.2	1.2
221414	3154	Aquarius	-15° 6193	22	14	32	-14	54.3	11.0	12.5	1.5
221507	3155	Aquarius	- 7° 5753	22	15	47	- 7	28.5	9.2	9.9	0.7
221715	3156	Aquarius	-16° 6074	22	17	54	-15	50.3	10.6	11.3	0.7
224613	3157	Aquarius	-13° 6289	22	46	46	-13	28.4	9.8	10.5	0.7
224909	3158	Aquarius	-10° 6016	22	49	42	- 9	54.5	10.5	11.5	1.0

REMARKS.

154315. This variable is probably of the Algol type.
161106. This variable is of the Algol type. Observations on plates taken between June 3, 1891, and July 13, 1906, are satisfied by the formula, J. D. 2410001.780 + 2^d.44596 E. Ten minima observed on plates taken in 1907 and 1908 occur too early, according to this formula. Recent observations are satisfied by the formula J. D. 2410002.320 + 2^d.44578 E.
161206. This variable is of the Algol type. Observations on plates taken between June 7, 1901, and July 6, 1908, are satisfied by the formula J. D. 2410001.704 + 2^d.06330 E.
161402. This star was near its maximum brightness on a large number of plates taken between May 5 and September 21, 1903. In 1904, during the same months, it was much fainter, and on several plates taken in 1905 it was estimated as of about the twelfth magnitude. The plates taken in 1906 do not show the object, with the exception of A 7701, taken May 28, 1906, on which the magnitude is about 14.5. It is also seen on A 3855, taken August 17, 1899, magnitude 14.5.
164012. Period apparently long.
164403. Period probably short. An eleventh magnitude star precedes about 4^s.
165202. Period probably long.
211000. Period short. A twelfth magnitude star follows about 6^s.
211102. Period does not exceed two months in length.
211411. This variable is perhaps of the Algol type.
211707. A twelfth magnitude star precedes about 6^s.
214012. Period probably long.
214505. Period probably long.
221507. This variable is apparently of the Algol type.
221715. This variable is apparently of the Algol type.
224613. This variable is apparently of the Algol type.

EDWARD C. PICKERING.

JULY 23, 1908.



HARVARD COLLEGE OBSERVATORY.

CIRCULAR 143.

STARS HAVING PECULIAR SPECTRA. 28 NEW VARIABLE STARS.

AN examination of the photographs of the Henry Draper Memorial, by Mrs. Fleming, has led to the discovery of a number of variable stars and other objects having peculiar spectra. A list of these is given in Table I. Three variable stars, *153620b*, *164167*, and *215628*, found by Miss S. E. Breslin, are included. The constellation and Durchmusterung number are given in the first two columns, The designations for stars north of declination -23° , in 1855, are taken from the Bonn Durchmusterung. For stars between declinations -23° and -52° the Cordoba Durchmusterung, and for stars south of declination -52° , in 1875, the Cape Photographic Durchmusterung is used. The approximate right ascension and declination for 1900, and the catalogue magnitude, are given in the third, fourth, and fifth columns. The class of spectrum and a brief description of the object are given in the sixth and seventh columns. The seventh column also contains the designation described in H. A. 53, 147, which indicates the number in the series of variables found at Harvard. Each of the new variables has been confirmed by Miss L. D. Wells, unless otherwise specified. Additional information regarding these objects is given in the Remarks following the Table. In the case of new variable stars, the right ascension is followed by the designation described in H. A. 48, 93, which gives the approximate position.

It will be noticed that several of these variable stars have a large range. Two become unusually bright, one attaining the magnitude 5.7, the other 7.0. The variations in H.A. 3181 appear to be peculiar.

TABLE I.
PECULIAR SPECTRA.

Constellation.	DM.	R. A. 1900.	Dec. 1900.	Magn.	Spectrum.	Description.
		<i>h. m.</i>	<i>° '</i>			
Cassiopeia	..	0 59.2	+59 53	..	O	Bright lines. Type V.
Horologium	-59° 250	3 1.0	-59 19	8.4	Md	Variable. H. V. 3159.
Taurus	+18° 877	5 27.6	+18 29	6.2	Bp	H β bright.
Volans	-66° 633	6 57.8	-66 59	9.6	Md	Variable. H. V. 3160.
Vela	..	10 26.0	-46 12	..	Md	Variable. H. V. 3161.
Vela	-52° 3999	10 49.4	-52 40	10.3	Md	Variable. H. V. 3162.
Carina	-57° 4494	11 11.2	-57 23	10.0	Na	Variable. H. V. 3163.
Centaurus	..	13 48.8	-60 40	..	O	Bright lines. Type V.
Lupus	-42° 9465	14 29.5	-42 56	8.3	Na	Variable. H. V. 3164.
Libra	-23° 12248	15 17.2	-23 42	9.3	Md	Variable. H. V. 3165.
Libra	..	15 36.2	-20 26	..	..	Variable. H. V. 3166.
Triang. Australe	..	15 39.3	-60 53	..	P	Bright lines. Gas. Neb.
Ara	..	16 28.3	-55 12	..	Md	Variable. H. V. 3167.
Ara	..	16 30.4	-59 36	9.3	Md	Variable. H. V. 3168.
Triang. Australe	..	16 41.6	-67 48	..	..	Variable. H. V. 3169.
Ara	..	16 46.0	-56 6	..	Md 5	Variable. H. V. 3170.
Scorpius	-39° 10898	16 49.6	-39 28	9.9	Me 5 d	Variable. H. V. 3171.
Draco	+64° 1176	17 7.8	+64 28	9.2	Me 5 d?	Variable. H. V. 3172.
Draco	+58° 1710	17 11.2	+57 59	9.2	Me	Variable. H. V. 3173.
Draco	..	17 31.8	+54 2	..	Md 8	Variable. H. V. 3174.
Scorpius	-41° 11893	17 33.4	-41 35	8.0	Pec.	Variable. H. V. 3175.
Ophiuchus	- 6° 4638	17 38.6	- 6 14	8.8	Ap	H β bright.
Sagittarius	-18° 4634	17 39.1	-18 37	8.5	Na	Variable.
Scutum	-13° 5083	18 38.7	-13 20	9.1	Na	Variable. H. V. 3176.
Scutum	-10° 4876	18 51.0	-10 39	9.0	Me 5 d	Variable. H. V. 3177.
Aquila	..	19 0.5	- 6 8	..	P	Bright lines. Gas. Neb.
Aquila	..	19 6.3	- 1 33	..	Na	Type IV. Variable. H. V. 3178.
Sagittarius	-24° 15190	19 11.6	-24 6	9.1	Md	Variable. H. V. 3179.
Sagittarius	..	19 19.7	-20 18	..	Md 5	Variable. H. V. 3180.
Telescopium	..	19 56.3	-56 0	..	..	Variable. H. V. 3181.
Pavo	-70° 2844	21 15.2	-70 10	8.5	Na	Variable. H. V. 3182.
Indus	R	21 38.4	-65 46	9.5	Na	Type IV. Variable. H. V. 3183.
Piscis Austrinus	..	21 56.8	-28 21	..	..	Variable. H. V. 3184.
Octans	..	21 58.8	-75 16	..	Md 9	Variable. H. V. 3185.
Aquarius	-11° 6062	23 17.5	-11 22	9.4	Me 5 d	Variable. H. V. 3186.

REMARKS.

h. m.

0 59.2. Galactic longitude, 92° 24'. Galactic latitude, -2° 2'.

3 1.0. 030159. An examination of thirty-nine chart plates, taken between October 6, 1892 and Septem-

h. m.

ber 5, 1907, shows a variation of about 2.3 magn. Estimates from these plates gave the approximate limiting magnitudes, 7.0 to 9.3.

5 27.6. H. R. 1858. On Plate C 17247, taken on

- h. m.*
January 10, 1908, $H\beta$ appears as a well marked bright line. The lines $H\gamma$ and $H\delta$ are very faint in this spectrum.
- 6 57.8. 065766. An examination of ten chart plates, taken between October 20, 1889 and November 16, 1904, shows a variation of about 5.0 magn. Estimates from these plates gave the approximate limiting magnitudes, 9.1 to 14.1.
- 10 26.0. 102646. An examination of ten chart plates, taken between May 13, 1890 and January 10, 1905, shows a variation of about 1.5 magn. Estimates from these plates gave the approximate limiting magnitudes, 10.5 to <12.0.
- 10 49.4. 104952. An examination of fourteen chart plates, taken between May 27, 1891 and January 9, 1905, shows a variation of about 4.6 magn. Estimates from these plates gave the approximate limiting magnitudes, 10.7 to 15.3. The star following $0^{\circ} 7'$ south $12''$, shows slight evidence of variation. Magn. 11.9 to 12.5. This change has been confirmed by Miss Wells.
- 11 11.2. 111157. An examination of fourteen chart plates, taken between May 17, 1894 and May 13, 1905, shows a variation of about 1.2 magn. Estimates from these plates gave the approximate limiting magnitudes, 8.8 to 10.0.
- 13 48.8. Galactic longitude, $278^{\circ} 20'$. Galactic latitude, $+0^{\circ} 14'$.
- 14 29.5. 142942. An examination of fourteen chart plates, taken between May 22, 1890 and July 3, 1902, shows a variation of about 1.4 magn. Estimates from these plates gave the approximate limiting magnitudes, 8.2 to 9.6.
- 15 17.2. 151723. An examination of thirteen chart plates, taken between June 19, 1889 and September 9, 1905, shows a variation of about 3.1 magn. Estimates from these plates gave the approximate limiting magnitudes, 8.6 to 11.7.
- 15 36.2. 153620b. An examination of eight chart plates, taken between May 16, 1891 and July 27, 1903, shows a variation of about 1.0 magn. Estimates made by Miss Breslin, from these plates, gave the approximate limiting magnitudes, 10.3 to <11.3.
- 15 39.3. Galactic longitude, $290^{\circ} 11'$. Galactic latitude, $-6^{\circ} 3'$.
- 16 28.3. 162855. An examination of twelve chart plates, taken between June 24, 1893 and May 4, 1904, shows a variation of about 5.1 magn. Estimates from these plates gave the approximate limiting magnitudes, 9.4 to 14.5.
- 16 30.4. 163059. An examination of twelve chart plates, taken between August 6, 1889 and May 8, 1908, shows a variation of about 3.7 magn. Estimates from these plates gave the approximate limiting magnitudes, 9.1 to <12.8.
- 16 41.6. 164167. An examination of one hundred and sixty-two chart plates, taken between July 9, 1889
- h. m.*
and October 6, 1905, shows a variation of about 3.1 magn. Measures of these plates, by Miss Breslin, gave the limiting magnitudes, 9.4 to 12.5.
- 16 46.0. 164656. An examination of ten chart plates, taken between June 11, 1891 and April 16, 1904, shows a variation of about 4.2 magn. Estimates from these plates gave the approximate limiting magnitudes, 9.3 to 13.5.
- 16 49.6. 164939. An examination of eighteen chart plates, taken between May 7, 1893 and September 5, 1900, shows a variation of about 4.5 magn. Estimates from these plates gave the approximate limiting magnitudes, 9.0 to <13.5.
- 17 7.8. 170764. An examination of thirteen chart plates, taken between February 22, 1891 and July 18, 1906, shows a variation of about 1.2 magn. Estimates from these plates gave the approximate limiting magnitudes, 8.8 to 10.0.
- 17 11.2. 171157. An examination of twenty chart plates, taken between August 13, 1893 and November 8, 1906, shows a variation of about 1.6 magn. Estimates from these plates gave the approximate limiting magnitudes, 8.1 to 9.7.
- 17 31.8. 173154. An examination of nineteen chart plates, taken between September 9, 1891 and August 31, 1908, shows a variation of about 2.2 magn. Estimates from these plates gave the approximate limiting magnitudes, 9.0 to <11.2.
- 17 33.4. 173341. An examination of thirteen chart plates, taken between July 17, 1893 and September 9, 1905, shows a variation of about 2.0 magn. Estimates from these plates gave the approximate limiting magnitudes, 11.4 to 13.4.
- 17 38.6. On Plate B 38082, taken on August 29, 1907, $H\beta$ appears as a well marked bright line.
- 17 39.1. 173918. An examination of eleven chart plates, taken between May 28, 1891 and April 5, 1905, shows a variation of 1.3 magn. Estimates from these plates gave the approximate limiting magnitudes, 8.5 to 9.8. This star was suspected of variability by Birmingham, in 1874. Monthly Notices, **34**, 412, but it has not, heretofore, been accepted as a variable star, neither has any letter been assigned to it.
- 18 38.7. 183813. An examination of twelve chart plates, taken between May 29, 1891 and May 6, 1903, shows a variation of about 1.5 magn. Estimates from these plates gave the approximate limiting magnitudes, 8.6 to 10.1.
- 18 51.0. 185110. An examination of thirty-three chart plates, taken between May 20, 1891 and July 12, 1907, shows a variation of about 1.4 magn. Estimates from these plates gave the approximate limiting magnitudes, 8.3 to 9.7.
- 19 0.5. Galactic longitude, $356^{\circ} 58'$. Galactic latitude, $-7^{\circ} 24'$.
- 19 6.3. 190601. An examination of nineteen chart plates, taken between April 30, 1893 and July 13, 1904 shows a variation of about 0.9 magn. Esti-

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| <p><i>h. m.</i></p> <p>mates from these plates gave the approximate limiting magnitudes, 10.8 to 11.7.</p> <p>19 11.6. <i>191124</i>. An examination of thirteen chart plates, taken between July 22, 1889 and July 1, 1903, shows a variation of about 5.3 magn. Estimates from these plates gave the approximate limiting magnitudes, 8.5 to <13.8.</p> <p>19 19.7. <i>191920</i>. An examination of eight chart plates, taken between April 30, 1893 and July 1, 1903, shows a variation of about 3.2 magn. Estimates from these plates gave the approximate limiting magnitudes, 9.3 to 12.5.</p> <p>19 56.3. <i>195656</i>. An examination of nineteen chart plates, taken between July 14, 1894 and July 1, 1907, shows a variation of about 2.5 magn. Estimates from these plates gave the approximate limiting magnitudes, 9.0 to <11.5. Plate A 3241, taken on August 3, 1898, shows that the star is about magn. 9.0, and at least a magnitude brighter than on any of the other plates examined. It may be a variable of the same class as SS Cygni.</p> <p>21 15.2. <i>211570</i>. H. R. 8156. An examination of twenty-five chart plates, taken between August 4, 1899 and</p> | <p><i>h. m.</i></p> <p>October 6, 1905, shows a variation of about 2.8 magn. Estimates from these plates gave the approximate limiting magnitudes, 5.7 to 8.5.</p> <p>21 38.4. <i>213865</i>. An examination of nineteen chart plates, taken between June 20, 1890 and August 9, 1905, shows a variation of about 1.0 magn. Estimates from these plates gave the approximate limiting magnitudes, 9.8 to 10.8.</p> <p>21 56.8. <i>215628</i>. An examination of thirteen chart plates, taken between August 25, 1889 and June 10, 1904, shows a variation of about 1.3 magn. Estimates, made by Miss Breslin from these plates, gave the approximate limiting magnitudes, 10.8 to 12.1.</p> <p>21 58.8. <i>215875</i>. An examination of nineteen charts plates, taken between September 27, 1893 and August 9, 1905, shows a variation of about 3.0 magn. Estimates from these plates gave the approximate limiting magnitudes, 8.0 to 11.0.</p> <p>23 17.5. <i>231711</i>. An examination of twenty-one chart plates, taken between August 13, 1891 and October 6, 1905, shows a variation of about 1.0 magn. Estimates from these plates gave the approximate limiting magnitudes, 8.4 to 9.4.</p> |
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EDWARD C. PICKERING.

OCTOBER 26, 1908.

HARVARD COLLEGE OBSERVATORY.

CIRCULAR 144.

EPHEMERIS OF MOREHOUSE'S COMET, (1908c), FOR 1909.

RECENT photographs show so large an amount of detail and such rapid changes in Morehouse's Comet, (1908c), that continuous observations of it, over as long a period as possible, are greatly to be desired. It is now rapidly approaching the Sun, and in the latter part of December it will be nearly in line with that luminary. Therefore, Professor Wendell has computed the ephemeris given in Table I, which shows the path of the comet, after perihelion. The elements assumed are those given in Circular 139 of the Lick Observatory, and are based on observations made on September 3, 11, and 18, 1908. It may be expected that they fairly represent its path in the spring, owing to their close agreement with the positions derived from the elements found by Kobold, *Astron. Nach.* 179, 47, and adopted by him in computing the ephemerides, during 1908, published in that periodical. On July 12, 1909, the position derived from these last elements precedes $0^m.1$, and is $4'$ north of the position given in Table I.

TABLE I.

EPHEMERIS OF MOREHOUSE'S COMET.

J. D.	Date.		R. A.		Dec.		log r.	log Δ .	Light.
	1909.		<i>h.</i>	<i>m.</i>	$^{\circ}$	$'$			
8320.5	January	13.5	18	49.5	-29	8	0.000	0.285	3.48
8330.5	"	23.5	18	49.2	-34	2	0.030	0.272	3.23
8340.5	February	2.5	18	48.3	-39	24	0.064	0.251	3.04
8350.5	"	12.5	18	45.8	-45	33	0.101	0.221	2.94
8360.5	"	22.5	18	39.6	-52	53	0.138	0.186	2.91
8370.5	March	4.5	18	23.3	-61	44	0.174	0.149	2.92
8380.5	"	14.5	17	35.1	-71	54	0.208	0.118	2.89
8390.5	"	24.5	14	33.1	-79	37	0.240	0.102	2.69
8400.5	April	3.5	10	39.9	-73	48	0.271	0.108	2.27
8410.5	"	13.5	9	34.5	-62	13	0.299	0.135	1.76
8420.5	"	23.5	9	15.5	-51	36	0.325	0.186	1.23
8440.5	May	13.5	9	10.7	-36	34	0.373	0.297	0.59
8460.5	June	2.5	9	19.0	-28	6	0.416	0.400	0.30
8500.5	July	12.5	9	45.1	-21	16	0.488	0.550	0.11

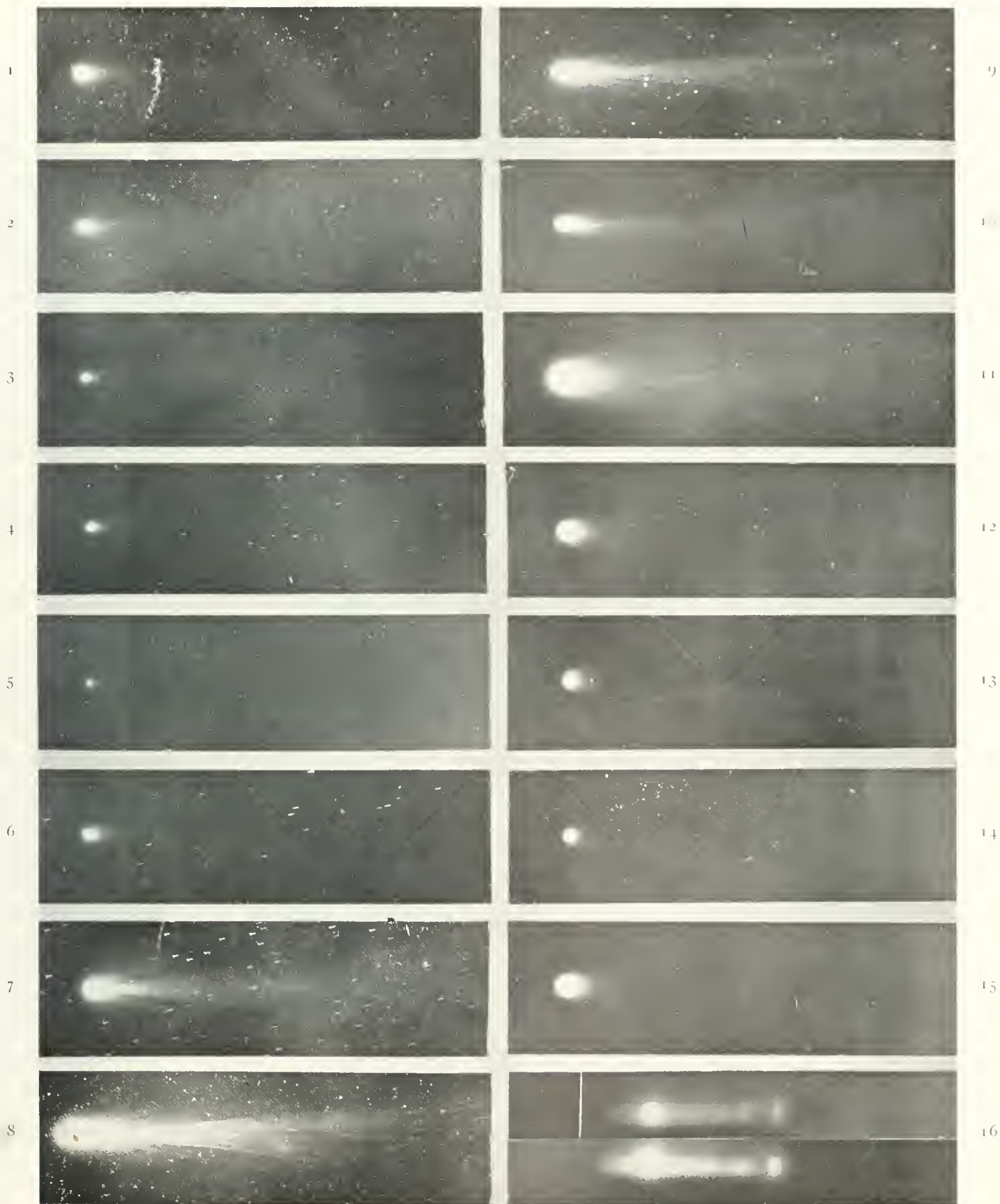
It will be noticed that this object affords a great opportunity to astronomers in the southern hemisphere, especially to those provided with good photographic doublets. The computed brightness given in the last column indicates that the comet even at the end of April will be as bright as it was when discovered. As, however, the comet presents a surface, and is not a point of light, its distance from the Earth will affect its apparent size, and not its intrinsic brightness. The spectroscopic observations, made at the Yerkes Observatory, H. B. 243, show that the comet is self luminous, and that but a small portion of its light is reflected from the Sun. In that case, its brightness would be independent of its distance from the Sun, except so far as it is affected by the heat, or other form of energy of the latter. As many comets, owing to the last cause, increase greatly in brightness as they approach perihelion, it is not improbable that this comet may undergo rapid changes next spring which can be photographed easily. It is expected that a good series of photographs will be obtained at the Arequipa Station of this Observatory, and also a series with a smaller instrument, in South Africa. Similar photographs in Australia are much to be desired, so that if the changes are still rapid they can be followed continuously.

A SEARCH FOR A PLANET BEYOND NEPTUNE.

As the result of an investigation, an abstract of which was read at the session of the American Academy of Arts and Sciences, November 11, 1908, and which will be published in full in H. A. 61, Part II, Professor W. H. Pickering finds evidence of the existence of a planet lying beyond Neptune, which in 1909.0 will be located approximately in R. A. $7^h 47^m$, Dec. $+21^\circ$. Photographs of this region have already been taken at Arequipa with the 24-inch Bruce Telescope, and similar photographs are now being made by the Rev. J. H. Metcalf with his 12-inch doublet. This region is now within easy reach, and it is possible that other astronomers would like to join in the search. If so, a systematic study of this portion of the ecliptic might be desirable.

PHOTOGRAPHS OF DANIEL'S COMET, (1907d).

During the summer of 1907, Daniel's Comet, (1907d), became a conspicuous object, and photographs of it showed much detail and rapid changes in its tail. Owing to its proximity to the Sun, it was only visible for a brief time in the morning, at any one station. Fortunately, photographs of it were taken at a number of observatories in different longitudes, and, therefore,

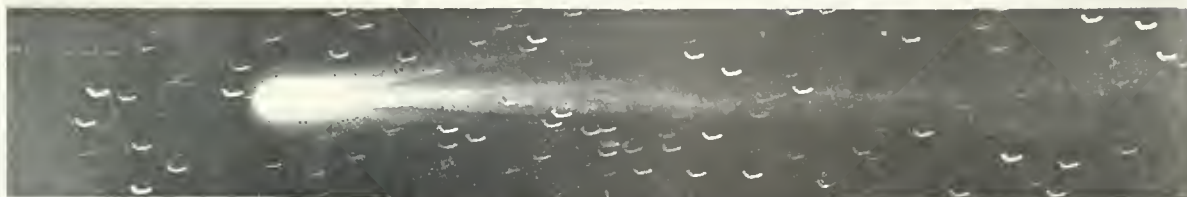


DANIEL'S COMET 1907 d.

17



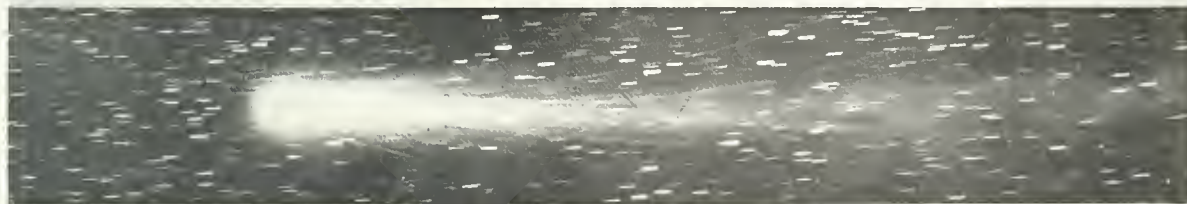
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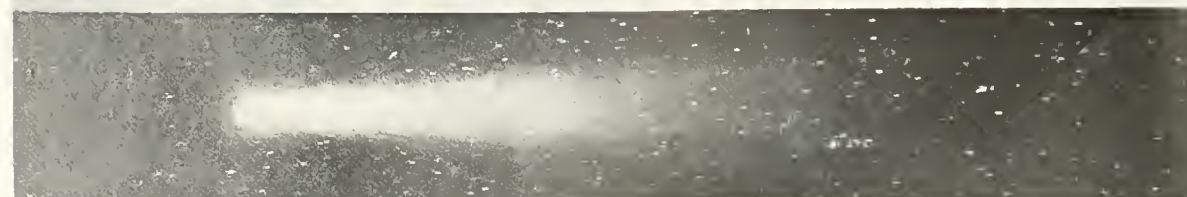
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DANIEL'S COMET 1907 d.

at different absolute times. It is hoped that a study of all of these photographs may lead to a knowledge of the nature of the changes, both in character, and in amount. A list of the photographs, taken here and at Arequipa, is given in Table II. The successive columns give the date, the Julian Day and decimal following Greenwich Mean Noon, the instrument, the time of exposure in minutes, and the corresponding number of the figures in Plates I and II. In the third column, the letter a indicates that the instrument employed was the 24-inch Bruce Telescope, b the 8-inch Bache Telescope, i the 8-inch Draper Telescope, and m, a 1-inch Cooke Anastigmat. The Draper Telescope is mounted at Cambridge, the other instruments at Arequipa.

In Plates I and II the contrast is increased by using double contact prints instead of the original negatives. The scale of Figures 11, 12, 13, 14, and 15 is

TABLE II.
LIST OF PHOTOGRAPHS.

Date.	J. D.	I.	Ex.	Fig.	Date.	J. D.	I.	Ex.	Fig.
1907.			<i>m.</i>		1907.			<i>m.</i>	
July 12	7769.803	i	20	1	August 4	7792.925	a	1	13
" "	" .831	i	10	2	" 5	7793.858	a	1	14
" 13	7770.800	i	10	3	" "	" .875	b	60	17
" "	" .821	i	30	4	" "	" .898	m	80	18
" 14	7771.829	i	10	5	" 6	7794.891	b	60	19
" 18	7775.815	i	36	6	" 7	7795.887	a	1	15
" 21	7778.815	i	30	7	" "	" .888	b	60	20
August 4	7792.901	a	10	11	" 11	7799.895	b	33	21
" "	" .902	b	30	8	" 17	7805.909	b	28	22
" "	" .916	m	48	9	" 21	7809.908	b	30	23
" "	" .917	b	10	10	" 25	7813.914	b	20	24
" "	" .919	a	1	12					

60"=0.1 cm.; for Figures 8, 10, 17, 19, 20, 21, 22, 23, and 24 it is 179"=0.1 cm.; for Figures 1, 2, 3, 4, 5, 6, and 7 it is 163"=0.1 cm.; for Figures 9 and 18 it is 180"=0.1 c.m. The last two photographs were enlarged 3.4 times, to bring them to this scale.

Figure 16 contains prints of the spectrum of the comet, taken on August 6 and 7, 1907, with the 13-inch Boyden Telescope at Arequipa, with exposures of 30^m and 39^m, respectively.

EDWARD C. PICKERING.

NOVEMBER 30, 1908.

MAR 1 1901

HARVARD COLLEGE OBSERVATORY,

CIRCULAR 145.

A SIXTH TYPE OF STELLAR SPECTRA.

THE work of the Henry Draper Memorial, in the study and classification of stellar spectra, has disclosed a veritable mine of objects of unusual interest, and has added many new facts to our knowledge of the constitution and distribution of the stars. From an examination, by Mrs. Fleming, of plates obtained at Cambridge with the 8-inch Draper Telescope, and at Arequipa, with the 24-inch Bruce and 8-inch Bache Telescopes, great additions to our lists of objects having peculiar spectra have been made. These include stars of the fourth type, the fifth type which consists mainly of bright lines, gaseous nebulae, spectra in which one or more of the hydrogen lines are bright, several new stars, and variables having bright hydrogen lines in spectra of the third type. Lists of these objects have been announced, from time to time, in various scientific journals, and later in the Harvard Circulars.

In H. C. 9, seven stars are described in the Table as having spectra of the fourth type. Following the Table, the statement is made that "Of the seven stars whose spectra are here announced as of Type IV, the first, second, and seventh are normal. The spectra of the others contain rays of much shorter wave length than ordinary fourth type stars." In H. C. 60, five stars, the brightest being of the ninth magnitude, are announced as peculiar. They are there described as showing one or more dark bands, and resembling the spectrum of the fifth type reversed on a continuous spectrum. Other stars having similar spectra have been published in later circulars.

Attention has been called to the necessary work entailed in referring to earlier publications for statements regarding these spectra, and the question has been asked "Why not assign a Class to them, if they fall outside the Classes already known?" If this can be done, it will greatly simplify the announcement of other similar spectra. Therefore, these doubtful fourth type spectra, peculiar spectra, and peculiar spectra showing dark bands, have been re-examined, and a list of 51 stars, all that would certainly fall in this new class, so far as our present knowl-

edge extends, are given in Table I. With three exceptions, these spectra have been announced, and described from the Harvard photographs of stellar spectra. Two stars in the list were announced by Espin as fourth type, and one from early Harvard visual observations. A few remarks, referring chiefly to announcement, follow the Table.

TABLE I.
STARS HAVING SPECTRA OF TYPE VI. CLASS R.

Designation.	R. A. 1900.	Dec. 1900.	DM. Magn.	H. C.	Designation.	R. A. 1900.	Dec. 1900.	DM. Magn.	H. C.
	<i>h. m.</i>	<i>° '</i>				<i>h. m.</i>	<i>° '</i>		
+53° 66	0 19.1	+53 44	9.3	R	-81° 782	16 58.4	-81 26	9.6	124
-48° 313	1 10.2	-48 47	9.4	98	-81° 787	17 11.0	-81 31	9.2	124
-59° 117	1 36.2	-59 46	10.2	R	-49° 11366	17 14.6	-49 22	10.0	60
-10° 513	2 30.2	-9 53	8.0	R	-41° 11533	17 15.3	-41 39	8.3	R
+57° 702	3 3.8	+57 31	7.9	R	..	17 53.2	+64 9	..	98
..	3 26.8	+45 25	..	R	-43° 12354	18 5.9	-43 43	10.0	60
-43° 1198	3 46.8	-43 50	8.5	98	-15° 4923	18 13.6	-15 39	9.0	R
+61° 667	3 57.2	+61 31	7.5	R	-38° 12843	18 23.4	-38 29	9.5	9
R	4 8.0	-70 3	..	R	..	18 29.5	-31 47	..	92
-69° 642	6 39.6	-70 0	9.7	R	-51° 11725	18 35.2	-51 51	9.3	R
-3° 1685	6 56.0	-3 6	7.7	R	+6° 3898	18 37.1	+6 43	9.0	132
-29° 6735	8 42.4	-29 22	7.9	R	-31° 15954	18 40.0	-31 27	9.2	9
+50° 1603	8 56.2	+50 29	9.2	92	-29° 15574	18 52.4	-29 38	8.9	9
..	9 2.2	+21 58	..	R	-17° 5492	19 3.0	-17 26	9.6	R
+14° 2048	9 8.3	+14 37	8.8	R	-10° 5057	19 17.6	-10 54	7.0	124
..	9 44.4	+53 7	..	132	+85° 332	19 44.0	+85 9	9.2	9
-49° 5234	10 21.0	-49 54	9.6	132	-65° 3832	19 47.0	-65 38	9.2	32
-47° 5992	10 30.3	-47 53	9.3	60	-62° 6147	20 5.7	-62 35	8.6	R
-47° 6614	11 8.6	-47 41	9.9	76	-12° 5755	20 26.2	-12 13	9.2	9
-13° 3407	11 30.7	-14 2	8.5	R	-19° 5930	20 43.2	-19 24	9.5	R
-57° 5169	11 54.9	-58 3	9.9	60	-54° 9810	21 3.2	-54 7	10.0	76
..	12 42.2	+4 42	..	R	..	21 36.6	-65 30	..	32
..	12 50.7	-57 21	..	76	+20° 5071	21 59.7	+20 34	8.7	98
-53° 5658	13 26.4	-53 19	9.4	R	-21° 6376	23 6.3	-21 33	9.0	132
-2° 3939	14 58.8	-2 28	9.6	92	+5° 5223	23 44.0	-5 50	8.7	9
-24° 12084	15 21.9	-24 50	7.6	R					

REMARKS.

h. m.

0 19.1. Not previously announced.

1 36.2. Not previously announced.

2 30.2. Announced by Fleming as Class Nd, Pec. Astron. Nach. **126**, 163.

3 3.8. Announced in Astron. Nach. **99**, 377, as Type IV, from early visual observations.

h. m.

3 26.8. Not previously announced.

3 57.2. Announced as Type IV, by Espin. Astron. Nach. **117**, 49.

4 8.0. This star is Gillis 2351, and is not in the Cape Photographic Durchmusterung. Not previously announced.

<i>h. m.</i>		<i>h. m.</i>	
6 39.6.	Not previously announced.	15 21.9.	Announced as Nd Pec. by Fleming, in <i>Astron. and Astrophys.</i> 13 , 767.
6 56.0.	Announced as Type IV, by Espin, in <i>Publications of the Liverpool Astronomical Society</i> .	17 15.3.	Announced as Peculiar, by Fleming, in <i>Astrophysical Journal</i> , 2 , 354. The images of this object are faint and not clearly defined, but it seems to have a spectrum consisting of dark bands, and would fall more nearly in this than in any other known class of spectrum.
8 42.4.	Announced as Type IV, by Fleming, in <i>Astron. and Astrophys.</i> 12 , 546.	18 13.6.	Announced as Type IV, by Fleming, in <i>Astron. and Astrophys.</i> 13 , 502.
9 8.3.	Announced as Type IV, by Fleming, in <i>Fourth Draper Report</i> .	18 35.2.	In H. C. 32, announced as Type IV, by Fleming. In H. C. 60, described as "Peculiar. Dark Bands."
11 30.7.	Announced as Class N, by Fleming, in <i>Astron. Nach.</i> 137 , 71.	19 3.0.	Not previously announced.
12 42.2.	The variable star, RU Virginis. The hydrogen lines $H\gamma$ and $H\beta$ are bright in the spectrum of this star.	20 5.7.	Not previously announced.
12 50.7.	The variable star, V Crucis. The hydrogen lines $H\gamma$ and $H\beta$ are bright in the spectrum of this star.	20 43.2.	Not previously announced.
13 26.4.	Announced as Class Nb 5 c, by Fleming, in <i>Astron. Nach.</i> 135 , 197.		

Enlargements of several of these spectra have been made, and are shown in Figure 1, together with photographs of U Hydrae, Type IV, Class Na; γ Velorum, Type V, Class Oa Peculiar; H. P. 1311, Type V, Class Ob; $-56^{\circ}55'10''$, Type I, Class A. Spectra of the last-named star are placed at the top and bottom of this group, to afford a means of identifying the lines due to hydrogen. A photograph of one of these peculiar stars, the variable star *125057*, V Crucis, serves to determine the wave lengths of the dark bands. The lines $H\gamma$ and $H\beta$ are present and bright in the spectrum of V Crucis, and, therefore, can be identified with certainty. These bright lines led to the discovery of the variability of this star. This variable and RU Virginis are the only stars having this Class of spectrum which, as yet, have been proved to change in light.

A strong dark band in photographs of spectra of this Class extends approximately from wave length 464 to 473. This band agrees almost equally well with the dark band in spectra of the fourth type, or with the strong bright band in spectra of the fifth type, like H. P. 1311, and γ Velorum. Other dark lines are present, among them one of slightly shorter, another of slightly greater, wave length than $H\gamma$. A broad dark band of slightly greater wave length than $H\delta$ is well shown in the photograph of $-24^{\circ}12'08''$, and the calcium lines K and H are also strong, well-defined lines in this spectrum, and in that of $-10^{\circ}50'57''$, photometric magnitude 7.04. The latter is the brightest star, now known, in this peculiar Class. Although the fainter spectra do not show the lines K and H, all appear to extend from about the region of $H\epsilon$ to that of $H\beta$, approximately.

An examination of the enlargements shows that these spectra cannot well be classed as fourth type stars, since they contain so much blue light, and stars having spectra of the fourth type are commonly regarded as red stars. They

cannot be called fifth type, since the spectra of stars of this type consist mainly of bright lines. A separate and distinctive Class would be more convenient for reference, and suggests the advisability of adopting Type VI, and Class R, to designate stars having this Class of spectrum.

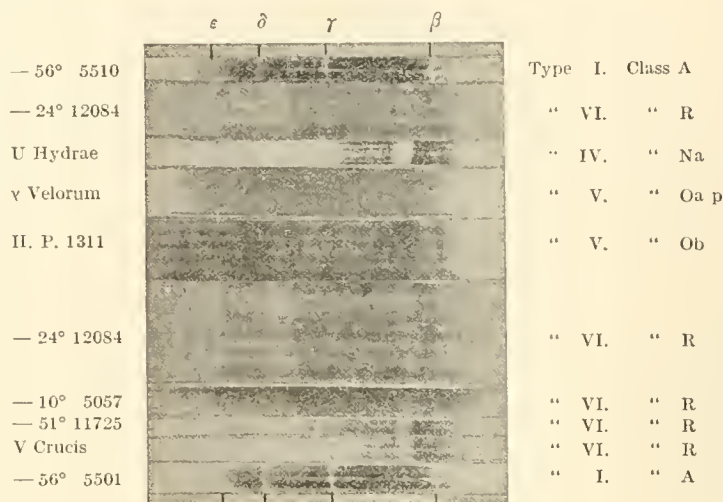


FIG. 1.

In the course of the examination of the objects described in this Circular, the spectra of three stars, —45° 14302, magn. 6.0, —70° 2844, magn. 8.5, and +2° 4709, magn. 6.2, were found to resemble each other very closely. They appear to have even less relation to any of the known classes of spectra, than those of the stars described above.

A photograph of the spectrum of Morehouse's Comet, taken on November 17, 1908, with the 8-inch Draper Telescope, shows six broad bright bands. These bands appear to coincide with the hydrogen lines $H\zeta$, $H\epsilon$, $H\delta$, $H\gamma$, $H\beta$, and the strong, bright band at wave length 464 to 473, characteristic of spectra of the fifth type.

EDWARD C. PICKERING.

DECEMBER 1, 1908.

HARVARD COLLEGE OBSERVATORY.

CIRCULAR 146.

THE CONSTELLATION CAMELOPARDALIS.

THE name of the constellation Camelopardalis, is also spelt Camelopardalus and Camelopardus in astronomical works in common use. It may be of interest to learn which of these forms is supported by the best authority. Three questions may be asked. 1. What is the best classical authority? 2. What is the usage among zoologists? 3. Which name is most commonly employed by astronomers?

Professor Morris H. Morgan has kindly answered the first of these questions as follows:—

Greek: The form is *καμηλοπάρδαλις*. It appears to be found first in the Alexandrine age, in the geographer Agatharcides (ap. Photium Cod. 455 b. 4, ed. Bekker). Curiously enough, on the margin of the principal MS. of Photius, there is in Greek a scholion by some unknown writer who says that he “once saw one of these creatures which had been sent to our king by the ruler in Alexandria, and the barbarian who brought the animal called it *ζοράφης*.” Thus is preserved the original Arabic (?) name or at least an attempt at it; for our modern dictionaries refer Giraffe to Arabic *Zurāja*. This, however, is beside your question. Besides in Agatharcides, the word *καμηλοπάρδαλις* is found in Diodorus Siculus (2,51), in Athenaeus (201C) and in Heliodorus (10,27). I am not aware that the word is found in any other form in Greek.

Latin: Here the oldest writers use a transliteration of the Greek just mentioned, and write *camelopardalis*; see Varro (L.L. 5,100), Pliny (N.H. 8, 69). In a writer of the third century after Christ, we find *camelopardalus*, i.e., in Capitolinus (Gord. III, 33); also in a fourth century writer, Vopiscus (Aur. 33); and the same form is in our printed editions of the Vulgate (Deut. 14,5). Finally, the form *camelopardus* occurs in the sixth century writer Isidorus (Orig. 12, 2, 19).

In view of this, if you want to call your constellation by the classical form of the name, both Greek and Latin demand *camelopardalis*. And this form is further vouched for by the classical Greek form of the word for 'panther.' It is *πάρδαλις* from Homer to Aristotle (see Liddell and Scott's Lexicon for the passages). The form *πάρδος* occurs in Aelian, second to third century after Christ (N.A. 1, 31; though one MS. gives *πάρδαλος* here, but it is not accepted by editors). In Latin, however, *pardus* is found three times in Pliny (N.H. 8, 63; 10,202; 11,172); also in Juvenal (11,123); and in the Vulgate (Jer. 13,23). The form *pardalis* occurs only in Curtius (5,1,22) who was a contemporary of Pliny. But *pardalus* does not seem to occur anywhere in Latin.

I have used the word 'panther,' but it should be noted that the Greek and Latin words which I have just been citing should not be too strictly confined to that species of animal; for I believe that the ancients did not always distinguish between panther, leopard, ounce, etc. etc., but used *pardus* and *pardalis* of any catlike animal with spots. To conclude, *camelopardalis* was the earliest Greek and Latin word for 'giraffe.'

Mr. Alexander Agassiz has courteously given the following answer to the second question:—

Camelopardalus, Jonst. is a pre-Linnean (1755) name, hence not in use. Camelopardalis, Gmelin, dates back to 1788. Linné called the Giraffe, *Cervus Camelopardalis*, 1780. Gmelin called it *Camelopardalis Giraffa*, 1788. The name *Giraffa* dates from Storr, 1780, who called the Giraffe, *Giraffa Camelopardalis*, and finally Brehm called it *Camelopardalis Giraffa*, in 1877. I do not find the name of *Camelopardus*. So that the present name of the Giraffe is *Giraffa Camelopardalis*. I get this from Seudder's Genera in Zoology.

In answer to the third question:—

This constellation was formed by Bartsch, and the name *Camelopardalus* was given to it by Hevelius, *Prodromus Astronomiae*, 1690, both in the Catalogue and on the Maps.

The spelling *Camelopardalus* also appears in the following works:—

Flamsteed. 1725. *Johannis Hevelii Catalogus Stellarum Fixarum*, 1660, p. 68.

Flamsteed. 1725. *Catalogus Britannicus*, 1689, p. 40.

Herschel, W. Fourth Catalogue of the Brightness of the Stars. *Phil. Trans.* 1799, p. 138.

Herschel, J. and South. Distances and Positions of 380 Double and Triple Stars. *Phil. Trans.* 1825, p. 67.

Argelander. *Uranometria Nova*, 1843, p. 4, and Map I.

Index. *Astron. Nach.* 1875, 61–80, p. 70.

Index. *Astron. Nach.* 1891, 81–120, p. 386.

The spelling *Camelopardalis* occurs in the following works: —

- Herschel, W. 145 New Double Stars. Mem. of the Astron. Soc. 1821, **1**, p. 10.
Heis. Atlas Coelestis Novus, 1872, p. 23, and Pl. I.
Astron. Nach. 1866. Index, **41–60**, p. 9.
Astron. Nach. 1902. Index, **121–150**, p. 383.
Vierteljahrsschrift der Astron. Gesell., 1908, **43**, p. 65.
Chandler. Third Catalogue of Variable Stars. Astron. Journ. 1896, **16**, p. 145.
Amer. Ephem. and Naut. Almanac, 1911, p. 305.
Encyc. Britannica, 1875, **2**, p. 817.
Century Dictionary, 1889, **1**, p. 777.

The spelling *Camelopardus* occurs in the following works: —

- Bailey. The British Catalogue of Stars, 1835, p. 383.
Bailey. The Catalogue of Stars of the British Assoc., 1845, p. 64.
Smyth. A Cycle of Celestial Objects. 1844, **1**, p. 409.
Webb. Celestial Objects for Common Telescopes, 1859, p. 175.
Schönfeld. Zweiter Cat. für Verän. Sternen, 1875, p. 16.
Chandler. Catalogue of Variable Stars. Astron. Journ. 1888, **8**, p. 86.

It, therefore, appears that the correct spelling, according to the best classical authorities both Greek and Latin, is *Camelopardalis*, which is that adopted by the zoologists, and is that commonly used in later standard works on Astronomy. The name given to the constellation by Hevelius, and followed by Flamsteed, W. Herschel, and other older astronomers, was *Camelopardalus*. The spelling *Camelopardus* was adopted by Bailey, Schönfeld, and others.

EDWARD C. PICKERING.

DECEMBER, 17, 1908.

MAR 3 1900

HARVARD COLLEGE OBSERVATORY.

CIRCULAR 147.

DISTRIBUTION OF THE STARS.

A STUDY is now being made of the results contained in the Revised Harvard Photometry, H. A. 50. The residuals from the various catalogues, compared in that work, are grouped according to their right ascension, declination, magnitude, position with regard to the Milky Way, and class of spectrum. A similar study has been made of the numbers of stars of different magnitude. It will be several weeks before these investigations are completed and printed. One result, however, seems of sufficient importance to bring at once to the attention of astronomers, since some of them are now engaged in similar investigations, and the announcement at this time of the new law may save superfluous work, and enable them to modify their plans, if necessary.

If the stars are infinite in number, and distributed throughout space according to the laws of chance, we should expect that, in any given class, the number, N , brighter than a given magnitude, M , would be represented by the formula $\log N = aM + b$, in which $a = 0.60$, and b is a constant dependent on the number of bright stars in that class. The first accurate determination of a is contained in H. A. 14, 483, where from a hundred thousand measures of four thousand bright stars, the value of a was found to be 0.52 instead of 0.60, with an uncertainty of less than ± 0.01 . The small value of a is commonly supposed to be due to an absorbing medium in space, a view which is confirmed by the darkness of the sky. Otherwise, the brightness of the latter should approximately equal that of the surface of the Sun. In H. A. 48, No. V, a further study of the distribution of the stars was made, extending the work to the fainter stars. This confirmed the value of a for the bright stars, and showed that, for fainter stars, it diminished gradually, attaining the value, 0.35, for stars of the twelfth magnitude. In H. A. 56, No. I, a study was made of the proportion of stars having different spectra,

in different parts of the sky, but without regard to brightness. Finally, H. A. 50, furnished so large an amount of material, more than a million observations of 9,110 stars, that the stars of each class of spectrum are sufficiently numerous to be grouped according to their brightness. They are accordingly divided into the Classes B, A, F, G, K, and M, using the notation first employed by Mrs. Fleming in the Draper Catalogue, H. A. 27, and since used in all the work of this Observatory, except in H. A. 28, Part I. From a study of the number of stars of different magnitudes, it appears that the spectra of Classes A and F, follow the same law. They have, therefore, been combined in the first part of Table I. Spectra of Classes G, K, and M, are similarly combined, for the same reason. The Milky Way evidently introduces a disturbing element which affects the distribution. Accordingly, the regions north and south of the Milky Way, covering one half of the entire sky, have been combined. The first column of Table I gives the limiting magnitudes of the groups. Thus, the first line relates to all stars brighter than the magnitude 4.25. The last line includes all stars in H. A. 50. The limiting magnitude is called 6.50, since all stars are included which have this magnitude, or brighter, in either of the photometric catalogues. Some fainter stars are thus included, but on the other hand, some slightly brighter stars have, doubtless, escaped observation in all the catalogues. Owing to this uncertainty, little weight should be given to the results derived from this line. The numbers of stars in the six groups into which the stars are divided are given in the second column, and the successive sums of these numbers are given in the third column. The logarithms of these numbers are given in the fourth column. The values computed by the formula $0.60 M - 0.753$, the residuals expressed in logarithms, and in magnitudes, are given in the next three columns. The second part of the Table gives the corresponding values for spectra of Classes G, K, and M, using the formula $0.60 M - 0.482$. The residuals are here large and negative. The last three columns, give the computed values and the residuals using the formula $0.51 M - 0.093$.

The average value of the residuals in the seventh column is ± 0.023 magnitudes. This quantity, small as it is, besides containing various accidental errors, is the sum of two systematic errors. These are, first, the deviation of the scale of the photometer from the truth, and secondly, the deviation of the law of distribution from that given by theory, assuming that there is no absorption. Of course, it is possible that these errors are equal and

TABLE I.

Classes A, F. Type I.							Classes G, K, M. Types II, III.								
<i>M.</i>	No.	<i>N.</i>	log <i>N.</i>	<i>C.</i>	O-C	Magn.	No.	<i>N.</i>	log <i>N.</i>	<i>C.</i>	O-C	Magn.	<i>C'</i>	O-C'	Magn.
4.25	65	65	1.813	1.797	+ .016	+ .04	117	117	2.068	2.068	.000	.00	2.074	- .006	- .02
4.75	57	122	2.086	2.097	- .011	- .03	97	214	2.330	2.368	-.038	-.10	2.329	+ .001	.00
5.25	127	249	2.396	2.397	- .001	.00	171	385	2.585	2.668	-.083	-.21	2.584	+ .001	.00
5.75	255	504	2.702	2.697	+ .005	+ .01	307	692	2.840	2.968	-.128	-.32	2.839	+ .001	.00
6.25	465	969	2.986	2.997	- .011	- .03	536	1228	3.089	3.268	-.179	-.45	3.094	- .005	- .01
6.50	398	1367	3.136	3.147	- .011	- .03	584	1812	3.258	3.418	-.160	-.40	3.222	+ .036	+ .09

opposite, and thus neutralize each other, but this is so improbable that it appears more likely that both are insensible. In other words, that the scale of the meridian photometer is the true photometric scale within less than one part in a hundred; and that the stars of Classes A and F follow the theoretical law with the same degree of precision. This view is strengthened by the values given in the second part of the Table. The residuals from theory differ nearly half a magnitude, the progression being nearly uniform. The residuals in the last column have an average deviation of ± 0.020 magnitudes, even including the last one, which should be rejected. Without it, they are insensible, and indicate that the law for stars of Classes G, K, and M is very nearly $0.51M + b$. It is difficult to understand how any absorption could affect unequally the number of stars whose spectra are unlike. A colored medium would affect the distribution of light in the spectra of stars at different distances, and thus would furnish an admirable means of determining that most important element. Rays of the same wavelength would be affected equally in all stars whatever their spectrum. The effect would be that one or more dark bands would appear whose density would increase with the distance, the change in the logarithm of the light of any portion of the spectrum, being proportional to the distance. It would not have any effect on the relative number of stars having different spectra if, as in the Draper Catalogue, the measures of brightness were all made of rays of the same wavelength. It is obvious that studies of the distribution of stars, will now have little value unless the stars are classified according to their spectra. Fortunately, the Henry Draper Memorial has not only furnished the means of doing this in the Revised Harvard Photometry, but by the plates enumerated in H. A. 56, 8, it enables the work to

be extended to much fainter stars. It furnishes also another example of the importance of considering the class of spectrum when studying any stellar problem, like that of the motion of the Sun in space.

It will be noticed that stars of Class B are not included in Table I. Contrary to expectation, these stars show no increase in number in the successive groups. The numbers of stars in the six groups are 135, 103, 163, 170, 146 and 105, respectively. This may be partly due to the difficulty, in faint stars, in distinguishing the helium lines characteristic of this class.

In conclusion, bright stars of the first type, Classes A and F, appear to follow closely the theoretical law, $a = 0.60$, as if there were no absorption in space. The number of stars of the second and third type, Classes G, K, and M, are well represented by the coefficient $a = 0.51$. The Orion stars, Class B, show no increase in number.

EDWARD C. PICKERING.

JANUARY, 14, 1909.

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MAR 3 1908
HARVARD COLLEGE OBSERVATORY

HARVARD COLLEGE OBSERVATORY.

CIRCULAR 148.

MOREHOUSE'S COMET. 1908 c.

AN admirable series of photographs of Morehouse's Comet, 1908 c, has been obtained by the Rev. Joel H. Metcalf at his Observatory in Taunton, Mass. The instruments employed were two doublets constructed by him. The first of these has an aperture of 12 inches, and a focal length of 87.5 inches. The second doublet has an aperture of 5.8 inches, and a focal length of 20 inches. The method which he has used so successfully, in discovering and following asteroids, was employed after September 15. The cross wires of a finding telescope were kept upon the image of a star, while the plate was moved every minute, by an amount, and in a direction, equal to the theoretical motion of the Comet, as determined from its ephemeris. This method proved particularly advantageous, since this Comet had no well defined nucleus which could be used for following in the ordinary way. The effectiveness of the method is shown by the smoothness of the trails of the stars. In all cases, two photographs were obtained simultaneously, with these telescopes, except on November 12, when the smaller instrument only was used.

A list of the photographs obtained is given in Table I. The number designating the plate is given in the first column. The numbers of the month and day are given in the second column, and the hour and minute in Greenwich Mean Time, in the third column. The Julian Day and decimal are given in the fourth, and the exposure, expressed in minutes, in the fifth column. The last two columns give the approximate right ascension and declination of the centre of the plate. The exposure of Plate 650 was interrupted for 20^m, and that of Plate 671, for 5^m, by clouds. The nights of October 15, 16, and 17 were hazy, and the night of November 23 was very hazy.

TABLE I.
LIST OF PHOTOGRAPHS.

Plate.	Date. 1908.		Time.		J. D.	Ex.	R. A.		Dec.	Plate.	Date. 1908.		Time.		J. D.	Ex.	R. A.		Dec.		
	m	d.	h.	m.		m.	h.	m.	°	'		m.	d.	h.	m.		m.	h.	m.	°	'
616	9	3	15	23	8188.641	30	3	24.0	+67	0	675	10	24	12	9	8239.506	60	19	10.0	+34	30
621	9	14	13	17	8199.553	60	2	6.0	+73	45	677	10	27	12	34	8242.524	60	19	3.0	+29	30
623	9	15	12	59	8200.541	60	2	0.0	+74	30	678	10	27	14	5	8242.587	42	19	4.0	+29	55
625	9	19	12	49	8204.534	60	1	7.0	+76	0	680	10	30	11	19	8245.472	50	19	4.0	+25	0
626	9	19	15	2	8204.626	137	1	7.0	+76	0	681	10	30	14	30	8245.604	60	19	4.0	+25	10
627	9	20	13	10	8205.519	120	0	37.0	+76	0	684	10	31	11	15	8246.469	50	19	2.0	+23	45
630	9	21	13	11	8206.549	120	0	26.0	+76	45	685	10	31	12	44	8246.531	59	19	2.0	+23	45
635	9	29	12	47	8214.533	90	21	56.0	+73	5	686	11	1	11	22	8247.474	60	19	1.0	+22	30
637	9	30	12	34	8215.524	89	21	45.0	+72	0	687	11	1	12	56	8247.539	113	19	1.0	+22	30
645	10	12	12	10	8227.507	60	19	36.0	+55	30	688	11	2	11	49	8248.492	30	18	57.5	+20	45
646	10	13	11	27	8228.477	30	19	33.0	+53	10	689	11	2	12	21	8248.515	30	18	57.5	+20	45
647	10	13	12	16	8228.511	60	19	33.0	+53	10	690	11	12	11	40	8258.486	120	18	57.0	+9	0
648	10	13	13	14	8228.551	16	19	24.0	+52	10	691	11	13	11	2	8259.460	50	18	56.0	+8	30
649	10	13	14	2	8228.585	30	19	34.0	+53	50	692	11	13	12	14	8259.510	84	18	56.0	+8	30
650	10	14	11	56	8229.497	60	19	32.0	+50	50	694	11	15	11	6	8261.462	60	19	0.0	+6	15
651	10	14	13	45	8229.573	120	19	32.0	+50	50	695	11	15	12	8	8261.506	61	19	0.0	+6	15
652	10	15	11	31	8230.480	30	19	30.0	+50	10	697	11	16	11	5	8262.462	60	18	53.0	+4	50
653	10	15	12	22	8230.515	60	19	30.0	+50	10	698	11	16	11	53	8262.495	22	18	53.0	+4	50
654	10	15	13	45	8230.573	90	19	30.0	+50	10	701	11	17	11	28	8263.478	60	18	53.0	+4	5
655	10	15	15	38	8230.651	90	19	30.0	+50	10	703	11	20	11	9	8266.465	70	18	55.0	+2	5
656	10	16	11	56	8231.497	78	19	27.0	+48	0	705	11	21	11	10	8267.465	76	18	58.0	+1	30
657	10	17	12	52	8232.536	156	19	22.0	+47	0	707	11	22	11	9	8268.465	68	18	57.0	+0	10
658	10	18	12	38	8233.526	120	19	12.0	+53	0	710	11	23	10	54	8269.454	8	18	54.0	-0	50
660	10	19	13	42	8234.571	90	19	18.0	+43	10	711	11	24	11	0	8270.458	60	18	54.0	-1	0
663	10	21	11	58	8236.499	90	19	14.0	+39	30	713	11	27	10	54	8273.454	49	18	58.0	-3	20
667	10	22	11	46	8237.490	60	19	9.0	+38	10	716	11	29	10	50	8275.451	44	18	57.0	-3	0
671	10	23	11	41	8238.487	62	19	14.0	+36	45											

Reproductions of Plates 694, 701, 703, and 705 are shown in the accompanying half-tone engravings. Following the example of the Lick Observatory, in the case of Daniel's Comet, L. O. Bulletin 126, double contact prints have been used to increase the contrast. Much detail is thus shown in the tail, although much of that near the nucleus is lost.

Reproductions of Plates 685 and 698 will be found in Popular Astronomy, 17, 53.

U.S. GOVERNMENT PRINTING OFFICE

1910



FIG. 1. NOVEMBER 15, 1908.



FIG. 2. NOVEMBER 17, 1908.

MOREHOUSE'S COMET.



FIG. 1. NOVEMBER 20, 1908.



FIG. 2. NOVEMBER 21, 1908.

MOREHOUSE'S COMET.

ORBITS OF ASTEROIDS.

IN a recent letter, Mr. Metcalf writes : "I now have about fifteen new asteroids which have been followed sufficiently long to assure good orbits. It was supposed that these orbits were being computed at the Naval Observatory in Washington. But a recent letter from the Acting Superintendent shows that such is not their intention. I must therefore appeal to the Astronomers of America to do this work, for the advancement of the Asteroid problem. I should be much pleased to hear from anyone who would be willing to make a contribution towards this work, by taking one or more of these planets."

The method employed by Mr. Metcalf, of giving a motion to the photographic plate equal to that of the asteroid, has proved extremely fruitful. Nearly all of the asteroids, discovered in America in recent years, have been found by him. The discovery of the asteroid, Eros, of the group whose mean distance is approximately that of Jupiter, and of the variations in light of several asteroids, has given a value to this department of astronomical research which it did not have previously. For two or three years, much useful work was done by the Naval Observatory in following the asteroids found by Mr. Metcalf, and it is hoped that its abandonment by the Naval Observatory is only temporary. It is eminently fitting that such work should be carried on by the government, as is done in Germany, since it cannot be maintained at private observatories. Meanwhile, some of the asteroids mentioned above will soon come to opposition. Unless ephemerides for them are computed, they cannot be found, and there is danger that they will be permanently lost. Therefore, it is greatly to be desired that, as requested by Mr. Metcalf, volunteers may be found at once, who will undertake the necessary computations.

EDWARD C. PICKERING.

FEBRUARY 1, 1909.

HARVARD COLLEGE OBSERVATORY.

CIRCULAR 149.

GROUP OF RED STARS IN THE CONSTELLATION SAGITTARIUS.

IN the examination of Draper Memorial photographs of stellar spectra, received from Arequipa last autumn, a large number of red stars having peculiar spectra were found, by Mrs. Fleming, on Plate B 39391. The plate was taken on July 30, 1908, with the 8-inch Bache Telescope, and had an exposure of 120 minutes. The part of the sky covered by the plate extends in right ascension from $18^h 48^m$ to $19^h 29^m$, in declination, from $-13^\circ.0$ to $-23^\circ.1$, (1900). It includes the north following portion of the constellation Sagittarius, and is in the southern border of the Milky Way. Besides twenty-one stars having spectra of the third type, and one of the sixth type, Class R, six stars of the third type having also bright hydrogen lines, Class Md, appear on the plate. Of these last six stars, four known variable stars, SU Sagittarii, T Sagittarii, Z Sagittarii, and 191920, (H. V. 3180) announced in H. C. 143, were found independently from their spectra on this plate, and two are new variables. One other star of the third type shows traces of bright lines and is suspected of variability.

A list of these objects is given in Table I. The successive columns contain the Durchmusterung zone and number, the right ascension for 1900, the declination for 1900, the Durchmusterung magnitude, the class of spectrum, and a brief description of the object.

In contradistinction to the results found in the region just described, a similar examination of Plate B 39203, taken on June 19, 1908, with the same instrument, the 8-inch Bache Telescope, and an exposure of 69 minutes, shows a dearth of red stars, although the numbers of spectra and limiting magnitudes for both plates are nearly comparable. The region extends in right ascension from $17^h 24^m$ to $18^h 11^m$, in declination from $-27^\circ.8$ to $-38^\circ.0$, (1900) and contains portions of the constellations Ophiuchus,

TABLE I.
PECULIAR SPECTRA ON PLATE B 39391.

DM.	R. A. 1900.		Dec. 1900.		Magn.	Spectrum.	Description.
	<i>h.</i>	<i>m.</i>	<i>°</i>	<i>'</i>			
-19° 5250	18	52.6	-19	19	8.8	Ma 5	Type III.
-19° 5255	18	53.5	-19	25	7.0	Mb	Type III.
-22° 4958	18	57.7	-22	51	8.5	Md 8	Type III. Variable. SU Sagittarii.
-15° 5204	18	57.8	-15	26	8.5	Mb	Type III.
-16° 5135	18	59.4	-16	51	9.2	Ma	Type III.
-15° 5220	18	59.7	-15	39	9.1	Mb 5 c	Type III.
-17° 5492	19	3.0	-17	26	9.6	R	Type VI. Peculiar. Dark bands.
-16° 5183	19	4.6	-16	27	9.0	Ma	Type III.
-16° 5186	19	5.1	-16	40	9.0	Ma	Type III.
-15° 5259	19	5.2	-15	15	7.5	Mb	Type III.
-16° 5198	19	6.5	-16	27	8.8	Ma	Type III.
..	19	7.5	-21	45	..	Md 4	Type III. Variable. H. V. 3187.
-19° 5347	19	8.0	-19	2	9.7	Mb 5	Type III.
..	19	8.2	-17	36	..	Md 4	Type III. Variable. H. V. 3188.
-17° 5546	19	10.5	-17	9	var.	Md 2	Type III. T Sagittarii.
-20° 5472	19	11.1	-20	46	9.6	Ma	Type III.
-19° 5388	19	12.5	-19	32	8.5	Ma	Type III.
..	19	13.8	-21	7	..	Md 6	Type III. Variable. Z Sagittarii.
-21° 5348	19	14.7	-21	9	9.4	Mb 5	Type III.
-17° 5588	19	14.8	-17	14	8.1	Md 4?	Type III. Variable?
-18° 5311	19	15.0	-18	23	9.2	Mc	Type III.
-17° 5603	19	17.0	-17	23	9.4	Ma	Type III.
..	19	18.3	-16	59	..	Mb	Type III.
-18° 5344	19	18.3	-18	34	9.5	Mb	Type III.
-13° 5345	19	19.5	-13	38	7.9	Mb	Type III.
..	19	19.7	-20	18	..	Md 6	Type III. Variable. H. V. 3180.
-16° 5310	19	20.9	-16	6	9.0	Ma	Type III.
-16° 5324	19	23.1	-16	20	9.0	Mb	Type III.
-16° 5332	19	24.0	-16	22	9.4	Mc 5	Type III.

REMARKS.

h. m.

19 3.0. This star is included since it belongs to the same Class as those published in H. C. 145.

19 7.5. 190721. An examination of fifteen chart plates, taken between April 30, 1893, and August 18, 1905, shows a variation of about 3.3 magn. Estimates from these plates give the approximate limiting magnitudes, 8.2 to <11.5.

19 8.2. 190817. An examination of fourteen chart plates, taken between August 26, 1896, and August

h. m.

18, 1905, shows a variation of about 2.5 magn. Estimates from these plates give the approximate limiting magnitudes, 9.2 to <11.7.

19 14.8. An examination of chart plates, taken between August 26, 1896 and August 18, 1905, shows a slight change, about 0.4 magn., in the light of this star. This slight difference may be due to differences in the photographs.

Scorpius, Sagittarius, and Corona Austrina. It, also, is in the southern border of the Milky Way, and is not far removed from the region shown on Plate B 39391. Table II contains a list of the stars having peculiar spectra on Plate B 39203, in the same form as Table I.

TABLE II.
PECULIAR SPECTRA ON PLATE B 39203

DM.	R. A. 1900.		Dec. 1900.		Magn.	Spectrum.	Description.
	<i>h.</i>	<i>m.</i>	<i>°</i>	<i>'</i>			
-32° 13223	17	37.0	-32	37	7.2	Mb	Type III.
-35° 11916	17	40.2	-35	42	9.7	Ma	Type III.
-35° 11923	17	40.8	-35	39	8.0	Na	Type IV. Variable. SX Scorpii.
-29° 14095	17	45.7	-29	36	9.4	Ma	Type III.
-30° 15065	17	53.4	-30	20	8.6	Ma	Type III.
-32° 13623	17	55.2	-32	43	8.7	O	Bright lines. Type V.
-36° 12130	17	55.7	-36	41	9.0	O	Bright lines. Type V.
-33° 12935	18	5.5	-33	53	10.0	P	Bright lines. Gaseous Nebula.
-28° 14266	18	5.6	-28	12	10.0	P	Bright lines. Gaseous Nebula.

It will be noticed that this region lies partly on the edge of one of the numerous dark lanes in the Milky Way, but even this fact would hardly account for the scarcity of red stars in this region, in proportion to the large number of stars of other classes shown on the photograph.

EDWARD C. PICKERING.

MARCH 20, 1909.

HARVARD COLLEGE OBSERVATORY.

CIRCULAR 150.

A STANDARD SCALE OF PHOTOGRAPHIC MAGNITUDES.

ONE of the most important problems now requiring solution by astronomers is the determination of the photographic magnitudes of the stars. A scale for visual magnitudes has been established at Harvard by more than two million photometric settings, extending over a period of thirty years. A summary of the results for the brighter stars and a discussion of them will be found in H. A. 50, 54, and 64,4. It is proposed to undertake here, an equally extensive investigation, for the determination of photographic magnitudes. As it is not probable that a similar research of equal extent will be undertaken elsewhere, it is essential that it should be based upon a correct scale. The consideration of this question is of special importance at the present time, as the Astrographic Congress will meet in Paris next month, and will consider the adoption of a scale of magnitudes, for the great work in which it is engaged. A scale must also be adopted for the reduction of the stars in the Selected Areas proposed by Professor J. C. Kapteyn. It would be a great misfortune if different scales should be employed in these three investigations. To secure uniformity, the decision regarding the scale to be used at Harvard may be delayed for a reasonable time. As the problem is of fundamental importance, the Harvard Observatory is prepared to devote a large part of its resources to the determination of photographic magnitudes, if a satisfactory scale can be adopted. A summary of the results, so far attained here, seems desirable at this time, to enable astronomers to decide what steps should next be taken.

In 1858, Professor George P. Bond proposed, in A. N. 49, 81, that the diameter of a stellar photographic image should be used as a measure of its photographic magnitude. This seems to be a good method for determining relative magnitudes when measuring the positions of large numbers of

stars. It has in fact been employed in the Catalogue of the Astrographic Congress, and as a basis for the magnitudes of the stars, nearly half a million in number, published in the Cape Photographic Durchmusterung. When precise magnitudes are desired, it has been found here that much more accordant results could be obtained by comparison with specially prepared scales, by Argelander's method, or by a direct estimate of the magnitude when the magnitudes of adjacent comparison stars, of nearly equal brightness, were available. Only relative magnitudes are thus obtained, and large errors are introduced in the attempts to derive absolute magnitudes from them. See also, Meeting of the Royal Astronomical Society, June 8, 1883, The Observatory, 6, 199, The Astronomical Register, 21, 150, and Stellar Photography, Memoirs Amer. Acad. 1886, 11, 179.

The principal publications of photographic magnitudes which have appeared in the Annals of the Harvard Observatory are described below. The principal observers are indicated by the letters, B, Professor S. I. Bailey; Bn., Miss S. E. Breslin; F, Mrs. W. P. Fleming; K, Mr. E. S. King; L, Miss H. S. Leavitt; Ld., Miss E. F. Leland.

18,7. Measurements of three catalogues of stars, by comparison with scales formed of images of the same star, with different exposures or apertures. These catalogues contain magnitudes of 1,009 stars within 1° of the North Pole, measured on nine plates; magnitudes of 420 stars in a region $15'$ square, included in the Pleiades, measured on eight plates. The third catalogue gives the magnitudes of 1,131 stars within 2° of the Equator, measured on twenty-four plates. The first and second of these catalogues contain all the stars in the given regions of the magnitude 15.0, and brighter. The third catalogue gives the magnitudes of trails of all the bright stars throughout a great circle, and great care was taken to eliminate systematic errors. Observer, F.

19,2. A Photographic Determination of the Atmospheric Absorption. The trails of 1,026 stars, in declination between $+55^\circ$ and $+65^\circ$, were photographed at upper and lower culmination, and measured by comparison with a series of standard trails. Observer, F.

26. Measurements of the difference in brightness of the two portions of the spectrum adjacent to the line $H\gamma$, for 3,480 stars having spectra of Class K. Also, measures of the spectra of 1,003 stars in clusters. Observer, F.

27. The Draper Catalogue gives the class of spectrum of 10,351 stars, and is derived from measures of 28,266 photographic images. It differs from other catalogues published here, or elsewhere, in giving the intensity of the light of

a single wavelength, 430. A discussion of the resulting magnitudes will be found in H. A. 64,4. Observer, F.

38. Observations of 128 variable stars in the cluster ω Centauri, on 124 photographs. About thirty thousand estimates were made by a modification of Argelander's method, each having a probable error of less than a tenth of a magnitude. The periods were generally determined to five places of decimals. Light curves were obtained, and their forms discussed. Observers, B, Ld.

47.1. Photographic magnitudes of 222 sequences of comparison stars for variables, discovered here by photography. The brightness was determined by comparison with a photographic scale, and probably gives the relative brightness of the stars with a high degree of accuracy. Observers, F, Ld.

48.1. Estimates of the magnitudes of 589 stars within 30' of the North Pole, including nearly all the stars brighter than the magnitude 15.5. The magnitude of each star was estimated on two plates, and the estimates agree closely. Observer, Ld.

53.1. Estimates of the magnitudes of 225 stars within 30' of the South Pole, including nearly all stars brighter than the magnitude 15.5. Magnitudes determined as in H. A. 48,1. Observer, Ld.

59.4. Photographic Magnitudes of Bright Stars. Determination of absolute magnitudes by images thrown out of focus. The first part of H. A. 59 shows some of the sources of error to be apprehended in determining photographic magnitudes. Observer, K.

60.5. Determination of the magnitudes of ten stars of the Algol type, eight found by direct comparison with the assumed magnitudes of the comparison stars, and two by Argelander's method. The average deviation of these estimates, about 3,700 in number, is ± 0.04 . Observer, L.

Investigations involving photographic magnitudes will also be found in H. C. 22, 44, 47, 50, 52, 65, 66, 69, 70, 88, 99, 104, 106, 108, 114, 115, 117, 120, 121, 125, 137, 138, 139.

Among the unpublished researches the following may be mentioned:—

Ledgers of about 300 variables discovered photographically, each star observed on an average of one hundred nights. Observers, Bn., F, Ld.

Measures of 16,400 images out of focus of northern stars. Observer, F.

Measures of wave length 430 in 10,069 spectra, with additional measures of stars of Class K. Observer, F.

Measures of 132 variables in Messier 3, and of 85 variables in Messier 5. Observers, B, Ld.

Measures of 15,985 stars of tenth magnitude, one in each square degree, mainly from declination 0° to $+30^{\circ}$, and a nearly equal number of bright stars. Observer, Ld.

Measures of 36 sequences of comparison stars, in regions 30° square, reduced to standard scale. Observer, Ld.

Measures of sequences of comparison stars and ledgers for 16 Circumpolar Variables. Observer, L.

Measures of 31 sequences of comparison stars and 71 ledgers of variables in the Small Magellanic Cloud. Observer, L.

Among the numerous sources of large error in deducing photographic magnitudes from the diameters of photographic images are the following:—Images not circular even in the centre of the plate. Distortion of images at a distance from the centre. Variation in form in different position angles, owing to differential refraction, inclination of plate, etc. Scale different on different plates, due to unequal sensitiveness, developer, temperature, etc. Difficulty in comparing plates in different portions of the sky. Nearly all of these difficulties are greatly reduced by the use of doublets, which cover much larger regions than ordinary objectives. For these and similar reasons nearly all the magnitudes in the above investigations must be regarded as provisional, and later should be reduced to the standard scale. In H. A. 18,7, the difficulty in comparing distant stars appears to be overcome. In H. A. 49,4, magnitudes of a few bright stars are determined on the absolute scale.

For twenty years, continuous efforts have been made here to overcome these difficulties, and finally the method proposed in H. C. 125 seems to furnish a complete and satisfactory solution of the problem, provided magnitudes can be found for a single sequence of polar stars. A photograph is taken on the North Pole, and a second exposure of exactly the same duration is then made on any desired region at the time when its altitude is the same as that of the Pole. Care must be taken to select a night on which the sky is perfectly clear. The two regions are thus superposed on one plate, and stars may be compared directly with the Polar Sequence even if in a remote portion of the sky. Regions far south of the Equator are never at the altitude of the Pole, in Cambridge. At the Arequipa Station of this Observatory, the South Pole is so low that this method cannot be used there advantageously. Accordingly, securing a set of photographs of the southern sky, taken in this way, will constitute an important part of the work of the expedition sent to South Africa, under the direction of Professor Bailey. This method has been used

here with entire satisfaction for several years, especially in determining the magnitudes of sequences of stars to the thirteenth magnitude in the centres of regions 30° square, into which the entire sky has been divided. An example of the application of this method is shown in H. C. 138.

As in the scale for photometric magnitudes, the unit corresponds to the ratio whose logarithm is 0.400. The two scales coincide for stars whose spectra are of the first type, or Class A.

A sequence of 47 polar stars has been selected, and a careful determination of their absolute magnitudes is now being made by Miss H. S. Leavitt. The series of measurements described below have been used to determine these magnitudes. In each series, the resulting magnitude of the star h , whose coordinates, from the North Pole in 1900.0, are $x = +134''$, $y = -267''$, is given, provided so faint a star appears on the photographs.

Photometric magnitudes were first taken from H. A. 50 and 54, for the brighter stars, and from measures with the 12-inch Meridian Photometer, for the fainter stars. Measures of 692 sets of four settings each with the latter instrument gave $h = 12.65$ magn.

Scale measures of four plates with the Ross-Zeiss Lens, aperture 0.5 in., exposure 60^m . h not seen.

Eight plates with the 1-inch Cooke Anastigmat, exposure 60^m . $h = 12.58$ magn.

Seven plates, Cooke Anastigmat, aperture 0.3 in., exposure 60^m . h not seen.

Four plates, 8-inch Bache Telescope, exposures 10^m to 119^m . $h = 12.56$ magn.

Twenty-five plates, 8-inch Draper Telescope, exposures 10^m . $h = 12.64$.

Eight plates, 8-inch Draper Telescope, exposures 60^m to 120^m . $h = 12.67$.

Five plates, 11-inch Draper Telescope, exposures 60^m to 120^m . $h = 12.72$.

Two plates, 12-inch Metcalf Telescope, exposures 60^m . $h = 12.76$.

Estimates by Argelander's method from four plates with 8-inch Draper Telescope, exposures 10^m . $h = 12.68$.

Four plates, 8-inch Draper Telescope, exposures 60^m to 120^m . $h = 12.65$.

Four plates, 13-inch Boyden Telescope, exposures 47^m to 77^m . $h = 12.64$.

Four plates, 24-inch Reflector, exposures 53^m to 240^m . $h = 12.68$.

Two plates, 12-inch Metcalf Telescope, exposures 60^m . $h = 12.64$.

The above measures were reduced to the photometric scale. The mean of the twelve values of h is 12.66, with an average deviation of ± 0.04 magn.

Eighteen plates, 8-inch Draper Telescope with small prism attached, which was assumed to reduce the light by 5.0 magn., exposures 10^m . $h = 12.63$.

Six plates, 8-inch Draper Telescope with small prism, exposures 60^m to 120^m . $h = 12.71$.

Nine plates, 8-inch Draper Telescope with larger prism, assumed to reduce the light by 2.7 magn., exposures 10^m . $h = 12.67$.

Three plates, 11-inch Draper Telescope with different apertures, exposures 10^m . $h = 12.63$.

Three plates, 11-inch Draper Telescope with different apertures, exposures 60^m . $h = 12.60$.

Three plates, 8-inch Draper Telescope with full aperture and covering each half in turn, gave bad images and discordant results owing to diffraction, exposures 10^m . $h = 12.60, 12.30$, and 12.12 , for the three plates.

Six plates, 11-inch Draper Telescope, exposures 10^m , gave $h = 12.61$, with accordant results from different plates.

Three plates, 8-inch Draper Telescope with and without a screen of shade glass, gave discordant results, $h = 12.85, 13.05$, and 12.67 .

Seven plates on Praesepe, with 11-inch Draper Telescope, interposing two thin plates of Iceland spar, gave fairly accordant results for stars of the eleventh magnitude, and brighter. The positions of the four images of each star served to determine their true relative brightness.

All of these last methods, including those with the auxiliary prism, determine absolute magnitudes and are independent of the photometric measures.

Measures are in progress by which the magnitudes of the Polar Sequence may be transferred to other sequences, and magnitudes thus obtained for stars in other regions. These include twenty sequences north of $+88^\circ$, containing stars from the ninth to the fifteenth magnitude. Thirty-two sequences north of $+75^\circ$, from the seventh to the twelfth magnitude. A large number of plates, each covering a region 30° square, have been taken with Cooke Anastigmats. A series of these plates covering the entire sky, as in the Harvard Map described in H. C. 71, is now being taken, with the Pole superposed, in Cambridge and in South Africa. From these, by means of the sequences described above, it will be possible to determine at once the magnitude of any star in the sky, of the magnitude 12.5 or brighter. Similar photographs are being taken, with isochromatic plates and orange screens, which will serve to determine the photometric magnitudes and colors of stars brighter than the eighth magnitude. Plans have been prepared for a catalogue giving the photographic magnitudes of all stars brighter than the magnitude 7.5. The magnitudes in the Cape Photographic Durchmusterung appear to be accordant for

stars photographed on the same plate, but they differ widely for stars in different parts of the sky. A plan, which seems to be entirely practicable, has been discussed with Professor Kapteyn, by which all could be reduced to the standard scale, and thus furnish accurate photographic magnitudes for nearly half a million southern stars.

To extend the Polar Sequence to the faintest possible stars, photographs of the North Pole, with the 60-inch Reflector of the Carnegie Solar Observatory, have been promised by Director Hale, with the 36-inch Crossley Reflector of the Lick Observatory, by Director Campbell, and with the 24-inch Reflector of the Yerkes Observatory, by Director Frost.

It will be seen that these various measures, although obtained from photographs made with different instruments and by employing different methods, are, in general, accordant and will determine the magnitudes of the stars of the Polar Sequence with an uncertainty of less than a tenth of a magnitude. If these magnitudes are adopted by astronomers, a basis will be established for standard photographic magnitudes, on a scale which will be the same in all parts of the sky.

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MARCH 22, 1909.

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